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Scientific and Technical Intelligence Report

A Delphi Examination of Future Soviet Strategic Military Objectives

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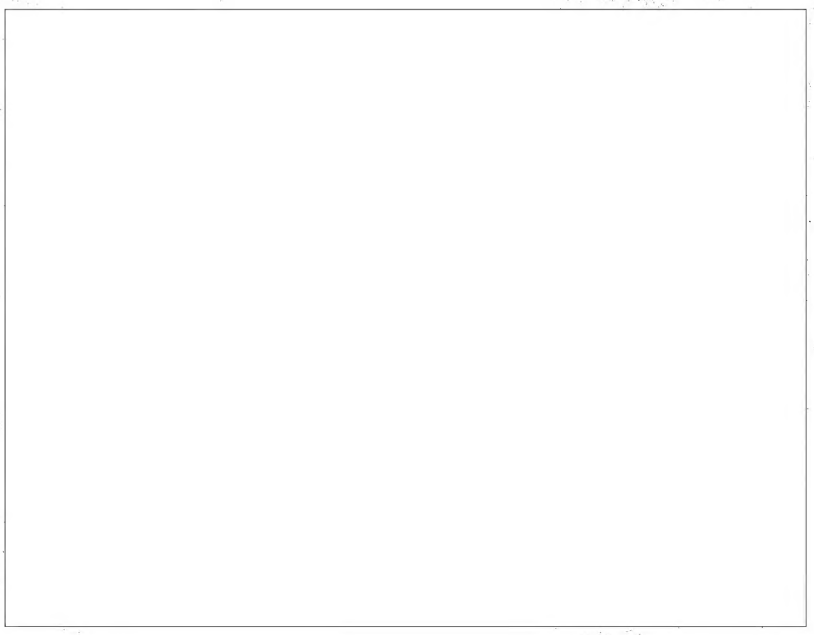

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A DELPHI EXAMINATION OF FUTURE SOVIET STRATEGIC MILITARY OBJECTIVES

Project Officer

[redacted]

OSI-STIR/71-17

August 1971

CENTRAL INTELLIGENCE AGENCY

DIRECTORATE OF SCIENCE AND TECHNOLOGY

OFFICE OF SCIENTIFIC INTELLIGENCE

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PREFACE

This report describes and presents the results of a Delphi (questionnaire) examination of the [redacted] of the relevance tree [redacted].* The Delphi participants, [redacted] CIA employees of diverse backgrounds (see appendix C), were asked to assign numerical values representing the priority that they felt the Soviet Union would place on obtaining significant improvement, or upgrading, of the various strategic alternatives in the relevance tree. The time frame of interest is 5 to 15 years in the future. The results of this exercise, conducted from November 1970 to April 1971, form requisite inputs to subsequent [redacted] studies and analyses concerned with the forecasting of possible future Soviet weapons and strategic systems. This report was produced by the Office of Scientific Intelligence. It was coordinated within CIA, but the reader is cautioned that its conclusions result from the application of a particular methodology and do not represent coordinated CIA opinion on the strategic military objectives of the USSR.

*Relevance tree: a structured array of objectives and alternatives, arranged as aggregates of activities, which a decision-maker might consider for future emphasis, improvement, upgrading, and/or investment. A vertical relevance tree starts with objectives and contains a hierarchy of sub-objectives.

[redacted]

TECHNICAL FOREWORD

The [redacted] of future threat identification involves a blend of inductive and deductive techniques and relies heavily upon the systematic use of experts to make quantitative judgments in specifically defined areas. The general philosophy consists of breaking down a large number of complex evaluations into relatively simple numerical assessments that can be stored, manipulated, analyzed, and easily revised. The methodology is based in part on the PATTERN (Planning Assistance Through Technical Evaluation of Relevance Numbers) system of relevance network analysis developed by Honeywell, Inc.[3-5] The relevance tree portion [redacted] is designed to assist in the identification and evaluation of Soviet military Specific Objectives (working-level tasks that may be performed to satisfy one or more national goals). The general relevance tree, beginning with Soviet national goals and ending with Specific Objectives, is shown schematically in Figure 1.*

The original PATTERN technique involved the development of specific criteria for each node, the asignment of weights to each of these criteria, and the assignment of relevance numbers to each alternative vis-a-vis each criterion. An overall weight attached to each alternative at a node is then obtained by forming a linear combination of the relevance numbers.**

Recent theoretical and experimental work indicates the feasibility of a "holistic" approach to the assignment of the overall weights to the nodal elements of the relevance tree. This variant to PATTERN was used in this exercise and required an individual to assign overall nodal

*For the purposes of this exercise, the term *element* will be used to designate any component entry in the relevance tree. The elements of the relevance tree are denoted by the boxes in Figure 1. A *node* will refer to a collection of elements, consisting specifically of the alternatives and the superior objective that they support. A node is often referred to as a branch point. An *alternative* at a node is one of the elements which represent means for attaining the objective. The alternatives at one level of the relevance tree become the objectives at the next lower level. The alternatives at a node are not necessarily mutu ''y exclusive and exhaustive.

**Consider a node having n alternative elements, e_j, $j = 1, 2, \ldots, n$, and a set of m criteria, C_k, $k = 1, 2, \ldots, m$. Then the nodal relevance number associated with the element e_j is given by

$$r_j = \sum_{k=1}^{m} W_k r_{jk},$$

where W_k is the weight (measure of importance) associated with criterion C_k, and r_{jk} is the relevance number of the element e_j based on a consideration of criterion C_k.

weights directly, taking into account implicitly the various criteria or bases for evaluation. Moreover, these weights were arrived at through formal application of the Delphi method, described in Appendix A. The combination of the Delphi and relevance tree techniques has been suggested before,[6,7] but this paper describes what is probably the first real application of that combination. It is of interest also to note that the "holistic" simplification of PATTERN has been suggested.[7]

In PATTERN [redacted] the nodal weights are combined mathematically to obtain weights associated with the various branches of the tree. The usual prescription is that the branch weights are formed from the product of the nodal weights in the levels superior to the branch element of interest.[4,5] In [redacted] the desired weights are primarily those for the Specific Objectives, from which a priority ranking may be obtained.

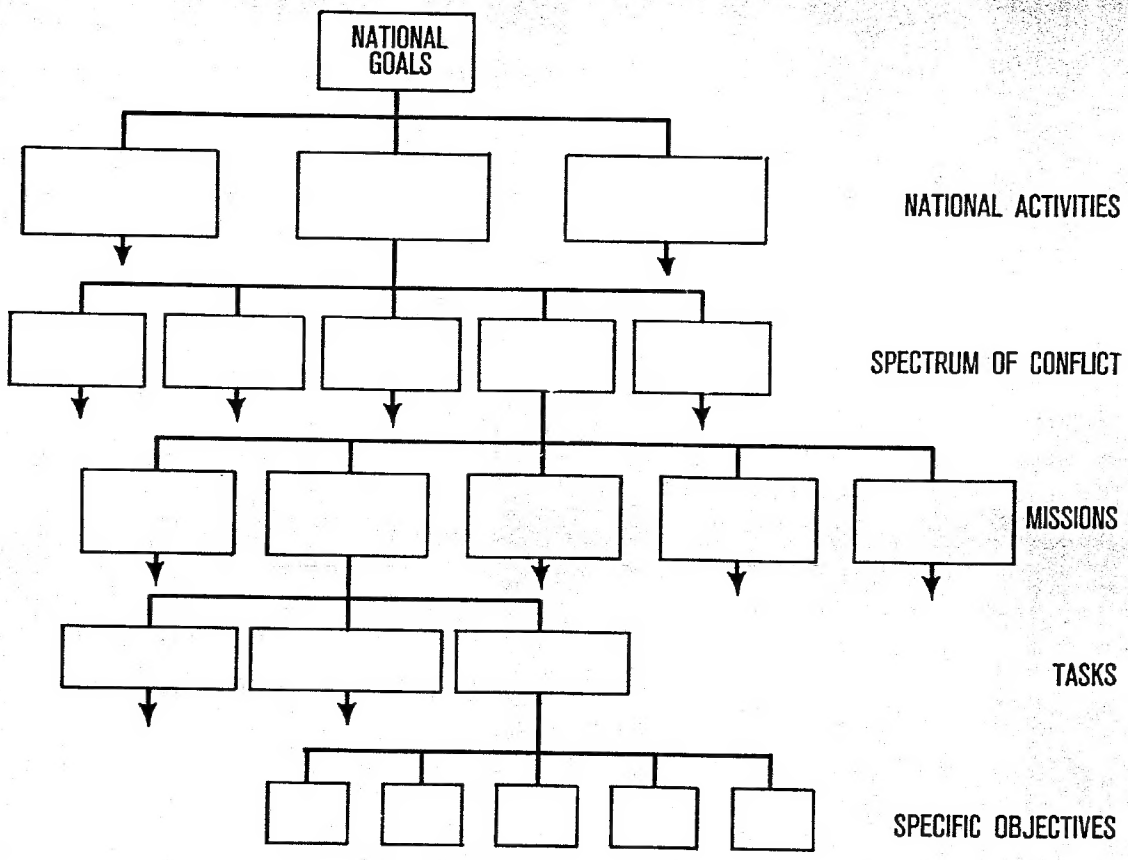

Figure 1. General Relevance Tree Structure for the [redacted] Methodology

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APPENDICES

A DELPHI EXAMINATION OF FUTURE SOVIET STRATEGIC MILITARY OBJECTIVES

SUMMARY AND CONCLUSIONS

A defined set of future Soviet strategic military objectives has been examined with a combination of the Delphi technique for elicitation of expert opinion and the relevance tree method for manipulation and aggregation of that opinion. The relevance tree, containing the objectives which were evaluated and ranked according to the priority which the Soviet Union might place on obtaining a significant improvement, or upgrading, over the next 5 to 15 years, is shown in Figure 2.

The opinions elicited in this exercise place high emphasis on defensive areas, with anti-ballistic missile (ABM), anti-aircraft, and early warning systems generally assigned top priority. Expected Soviet concern about enemy strategic forces as targets was exhibited by the high ranking attached to the counterforce capabilities against submarines, land-based missiles, and strategic aircraft. Anticipated future Soviet interest in the anti-submarine warfare (ASW) problem is also manifest by a high priority on ocean surveillance and naval command, control, and communications.

A limited examination of the sensitivity of the results to arms control indicated in the view of the participants an emergence of emphasis on Intelligence/Warning/Control objectives in the case of a fairly comprehensive restriction on offensive and defensive weapons.

Analysis of the data has suggested certain revisions or modifications in the methodologies employed to aggregate opinions in the relevance tree network. The results indicate areas of future work on such methods which might be fruitful and pertinent.

RANKINGS AND RELEVANCE NUMBERS

Rankings for the Task and Specific Objectives levels of the relevance tree have been obtained using various types of mathematical procedures for manipulation of the data collected in the Delphi process. Considering these variations and the observed sensitivities of the rankings with future arms control environments, the following (partial) rank-ordered list of Specific Objectives is a good representative summary:

411 Active Air Defense/ABM Systems
112 Destruction of Forces/Submarines
331 Strategic Intelligence/Early Warning
412 Active Air Defense/Anti-aircraft . . Systems
111 Destruction of Forces/Land-based Missiles
322 Operational Intelligence/Ocean Surveillance
312 Command, Control, Communications/Naval Forces
114 Destruction of Forces/Strategic Aircraft
321 Operational Intelligence/Satellite Surveillance
422 Air Defense/Mobile Basing

* * * * * * *

423 Air Defense/Deception Techniques
122 Destruction of Resources/Transportation
214 Strategic Mobility/Spacelift
432 Civil Defense/Protective Shelters
431 Civil Defense/Evacuation and Dispersal

Only the Specific Objectives near the top and near the bottom have been listed, since interest in the results will tend to focus on the most important items and those which may be safely ignored relative to the others. The top 10 Specific Objectives listed above are in the top 10 in almost every variation investigated, and the bottom five are almost always on the bottom, with variations generally in *exact* position or rank in both groups. In selecting a single set of relevance numbers or numerical weights and an associated ranking, it is

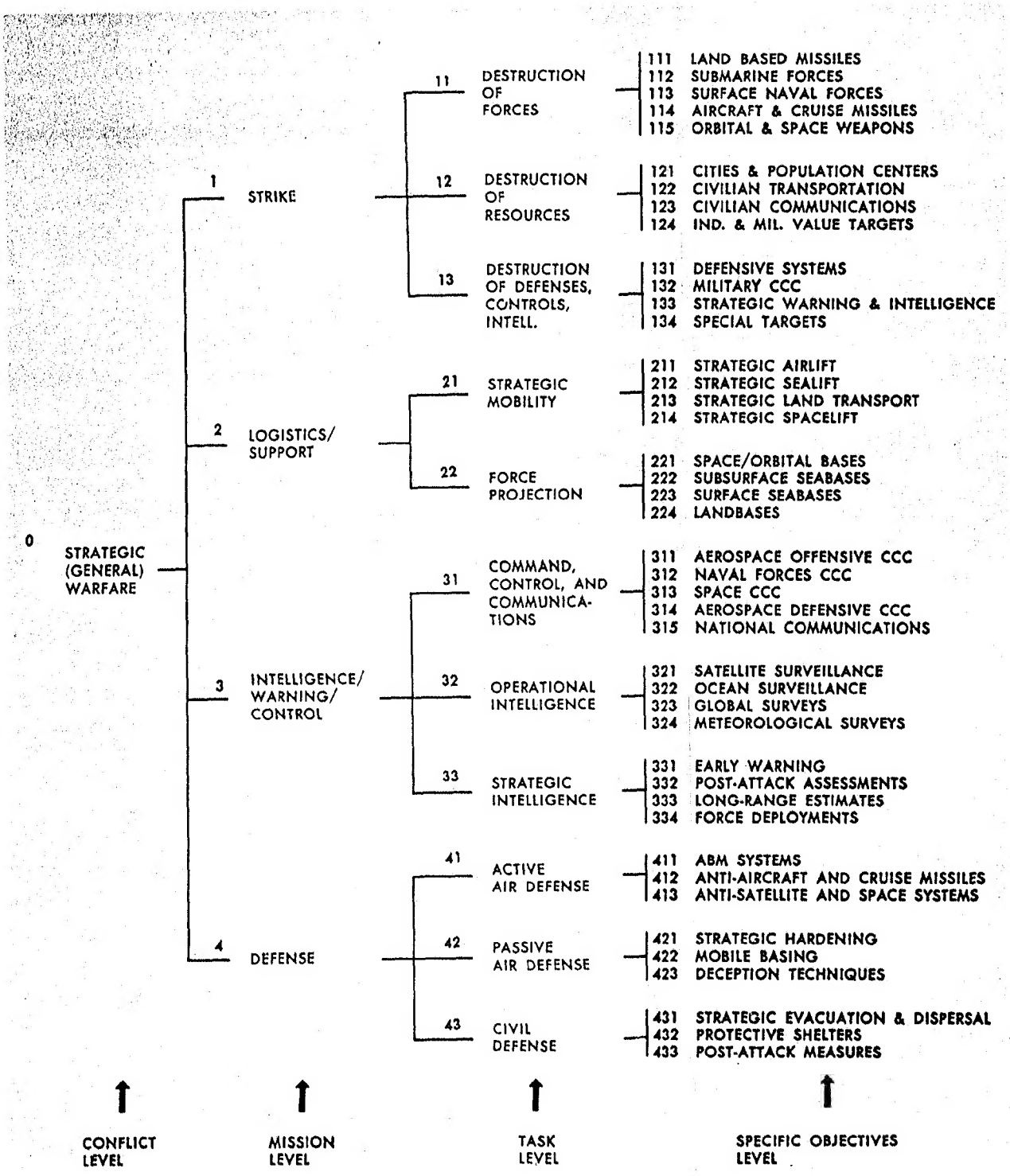

Figure 2. Relevance Tree for Strategic (General) Warfare.

Complete definitions of the elements are contained in appendix B. The number to the upper left of each element will be used as a form of shorthand to designate the element: the *node number* is defined as the number of the objective element in the node, for example, Node 4 is the node in which Defense (Element 4) is the objective and the alternatives are Active Air Defense (41), Passive Air Defense (42), and Civil Defense (43).

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probably best to choose the Round 2 product of the non-normalized (nodal) averages in table 7. The ranking for this case, shown in a staggered format which illustrates the broad (mission-level) categories of dominance, is shown below.

Although only five of the 16 nodes in the relevance tree were examined in Round 3 of the Delphi process under the three hypothetical Arms-Control Environments, it is believed that the results would not be significantly different if the remaining 11 had been included. Node 0 is probably the dominant factor in variation with arms control, with lesser influences from subordinate nodes. The one node examined at the task level, 41, did not exhibit great variations, even though it has ABM as an explicit alternative and ABM was specifically restricted in two of the hypothetical environments considered. Much more significant differences are apparently obtained from the manner in which the numerical assignments are manipulated and aggregated than from such substantive origins.

Specific Objectives

Rank	Defense	Intell/ Warning/ Control	Strike	Logistics/ Support
1	411			
2			112	
3	412			
4		312		
5		331		
6			111	
7		322		
8		321		
9		314		
10		311		
11			114	
12	422			
13		334		
14			131	
15		315		
16	413			
17			132	
18			113	
19			133	
20		333		
21	421			
22		313		
23			124	
24		323		
25			115	
26				212
27			134	
28				211
29		332		
30		324		
31				213
32				222
33			121	
34				224
35			123	
36	423			
37				221
38				223
39			122	
40	433			
41				214
42	432			
43	431			

Two major lessons were learned in the course of this exercise that impinge on future work with [redacted] 1) it is workable and beneficial to collect non-normalized assignments of an abstract quantity such as "priority" via the Delphi technique; 2) important assumptions or potential uncertainties, such as SALT and future arms control environments, should be considered explicitly. It has been found feasible to handle this by explicit definitions and a repeated evaluation of the given question for each assumption. For Delphi studies of the type considered here, two rounds appear sufficient, unless some significant fact turns up or initially unknown uncertainties appear and require further definition and iteration.

FURTHER ANALYTICAL POSSIBILITIES

Considering the richness and amount of data that was collected in the Delphi exercise, additional analyses might be performed. From a quantitative point of view, use could be made of various combinations of nodal assignments and normalization; more elaborate sensitivity analysis might be carried out; and, in particular, some effort might be expended in the analysis of the results [redacted] Some correlation studies might be attempted to better understand the results obtained in the third round (with the hypothetical Arms-Control Environments) as compared to, say, the second round. Finally, since a democratic procedure was used in the analysis reported here, that is, all results obtained were used and each respondent's assignments were weighted equally, it would be interesting to investigate the effects of restrictive selection of the results on each node, for example, by considering only the sub-set of respondents common to all three rounds

and/or an attendant weighting of those assignments (e.g., by using the self-ratings, which have thus far only been exploited in the original assignment process).

From a qualitative point of view, much might be done with the wealth of commentary provided by the respondents in Part B of the Delphi Questionnaires. At this time, the commentary has only been used by the participants themselves in the feedback process. The comments might well be studied more thoroughly and possibly interpreted in non-numerical context. Such a study could be compared with the numerical results to answer such questions as whether the numerical procedures preserve accurately the gist of the opinions expressed non-numerically.

Finally, from a strictly methodological point of view, the state of the art in both Delphi and relevance tree technology might be enhanced by a careful examination of the data obtained in this exercise. The non-normalized assignments which were collected at each node may lend themselves to a rigorous treatment of the question concerning the validity of multiplication between levels of the relevance tree; further experimentation is warranted to ascertain the validity of various corrections to the PATTERN results to counter the bias due to the actual structure of the tree. The qualitative analysis described above might well give some insight into both of these questions.

DISCUSSION OF RESULTS AND RANKINGS

A tabulation of the results obtained in the Delphi examination of the 16 nodes in the relevance tree is contained in Appendix D. This tabulation forms the basis for the results and analyses below. The distributions at each node are portrayed by the quartiles, medians, and means. The PATTERN process requires normalized data, and the usual procedure is to normalize the individual assignments at each node and then compute the (normalized) average of these. These results are shown in the far right-hand column. For comparison, the (non-normalized) averages have been normalized and tabulated in the second column from the right. It should be noted that there is general agreement between these last two columns. A simple measure of dispersion in assignments is obtained from the so-called Inter-Quartile Range (IQR), the difference between the upper and lower quartiles ($Q_3 - Q_1$). Note that, by definition, the IQR contains the middle 50% of the assignments. In the following sections some examples of results at individual nodes are presented, followed by the rankings obtained for the Specific Objectives (and Tasks) by combination of the nodal assignments.

EXAMPLES OF RESULTS AT NODES

Node 0 is probably one of the most interesting and important nodes in the entire relevance tree. As a consequence, this node merits some additional attention and description. The distribution of priority number assignments, in the form of the so-called Delphi houses, is shown in Figure 3. Here, one can observe the reduction in IQR on the second round as compared with Round 1. Also, it appears that the specification of an Arms-Control Environment in Round 3 results in yet further improvement in consensus for most of the elements at this node. The investigation in Round 3 of the Arms-Control sensitivity is described in Appendix C. Expansive definitions were given for the three hypothetical Arms-Control Environments (ACEs) considered. In simplest terms, the three environments are given in the table below.

Table 1

Short titles for the three hypothetical Arms-Control Environments (ACEs) investigated in the third round of the Delphi Exercise (see Appendix C)

ACE-0	Termination of negotiations
ACE-1	Limited (ABM) agreement
ACE-2	Full (offensive+defensive) agreement

An alternative way of presenting the results at Node 0 is that shown in Figure 4, in which frequency histograms for rank of the four elements are given. Such a representation emphasizes the

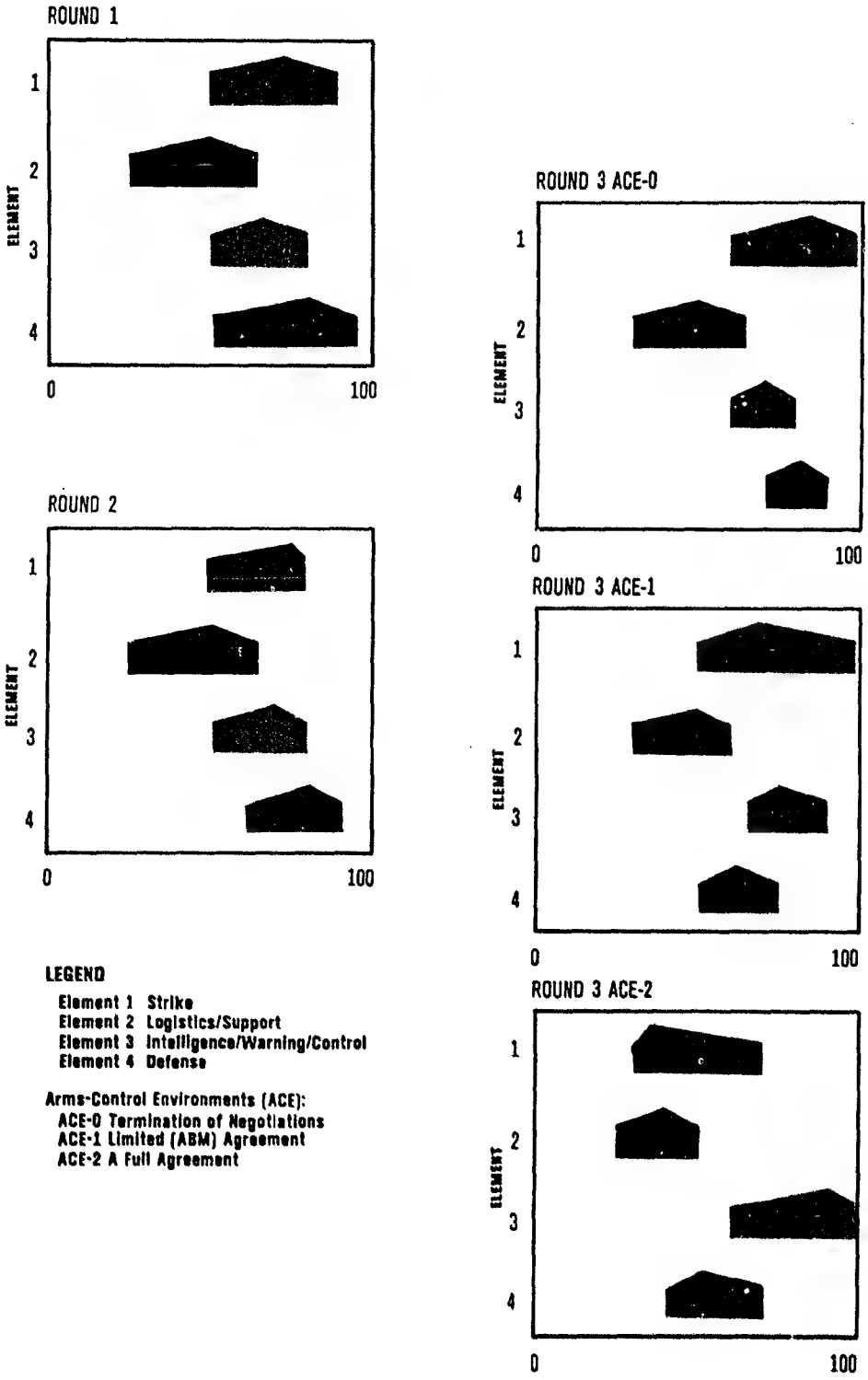

Figure 3. Representation of Nodal Assignments at Node O.

The houses are a shorthand way of denoting the distribution of assignments, in which the peak denotes the median and the walls denote the quartiles (Q_1, Q_3).

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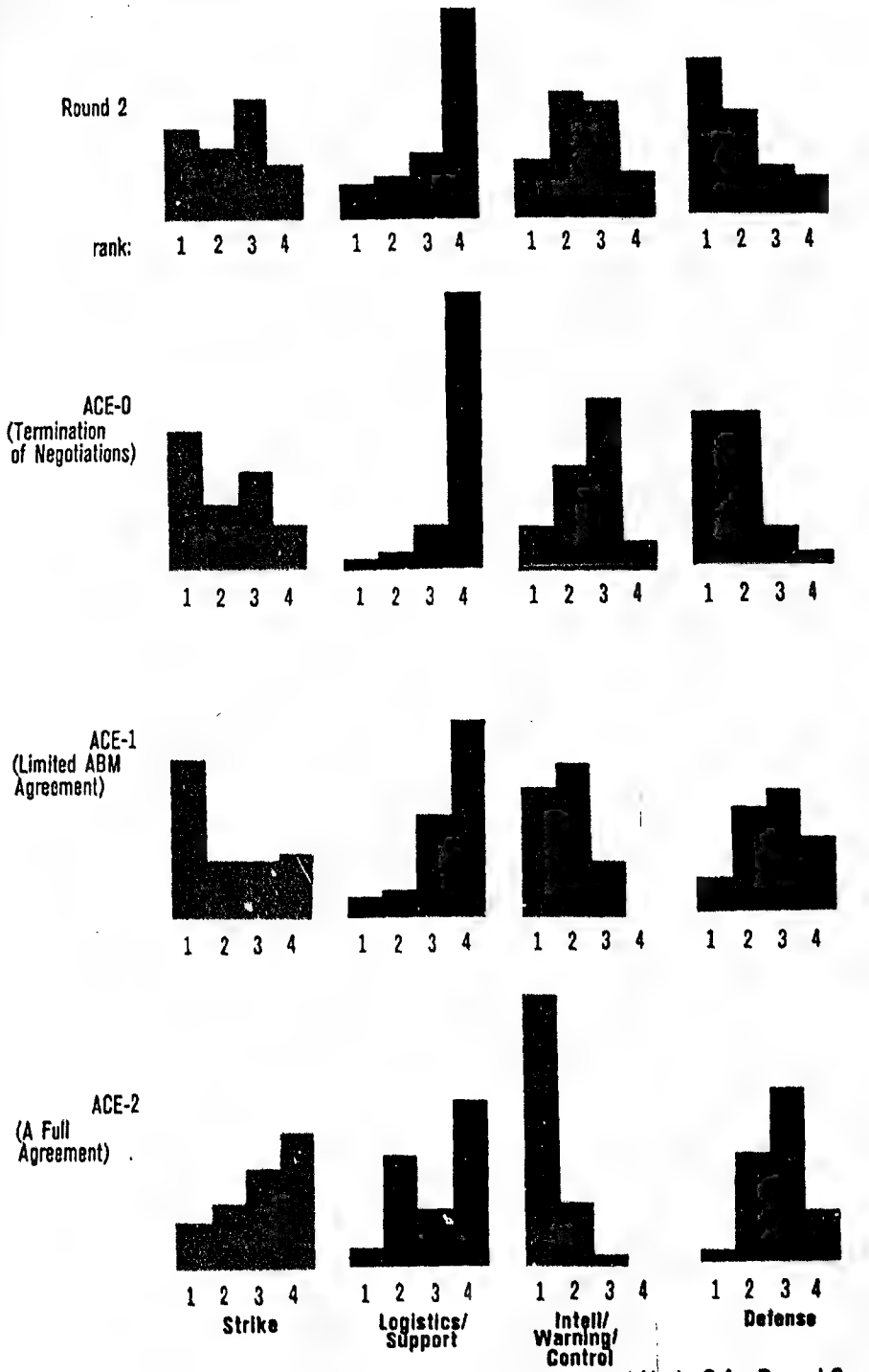

Figure 4. Frequency Histograms of Rank of the Elements at Node O for Round 2 and the Three Arms-Control Environments (ACEs) Considered in Round 3 (ACE Definitions in Appendix C).

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relative positions of the elements as indicated by the respondents and conveys a measure of certainty to be associated with the rank of a given element. In this figure, for example, one clearly sees the inferior position accorded to Logistics/Support (Element 2) in all cases—it was placed in fourth position by some 60% of the respondents on Round 2 and by as high as 79% in Round 3 (assuming ACE-0, termination of SALT negotiations). The emergence and dominance (in the case of a full Arms-Control Environment, ACE-2) of Element 3 (Intelligence/Warning/Control) is to be observed and probably more clearly so than was indicated in Figure 3. This Mission was ranked third by nearly half of the respondents in ACE-0, second in ACE-1, but first by an overwhelming 78% of the respondents in ACE-2.

The nature of the distributions of normalized assignments are of interest, particularly because the averages of such distributions are generally used in the PATTERN procedure to obtain rankings of the elements across an entire level of the relevance tree.[2,4] The few nodes with three alternatives lend themselves to a graphic illustration of such assignments in the form of *barycentric*, or triangular, coordinates, a technique well-known to physical chemists and metallurgists. This method uses the property of an equilateral triangle that the sum of the distances to the three sides from a point within is a constant. In this representation, a point in the very center of the triangle denotes an equal-weight assignment on all three elements, and a point at a vertex denotes a weight of 1 attached to the element cited at that vertex and a 0 to each of the other two elements.

Figure 5 illustrates the reduction in dispersion between rounds but with only slight shifts in the mean assignments. Figure 6 shows the distribution of assignments for the same node as shown in Figure 5 for each of the hypothetical Arms-Control Environments. It should be noted that the dispersion is slightly greater for ACE-2 than for either ACE-0 or ACE-1, a phenomena which appears to be the general case for the nodes investigated in Round 3. Figure 7 illustrates a case in which the dispersion was reduced between rounds and in which there was also a noticeable shift in the mean assignments. This figure also reveals an example of a hold-out from Round 1 which ended up quite removed from the consensus position on Round 2. Figure 8 illustrates a rather unusual result in that there was a rather definite lineal distribution formed on the second round. Most of the distributions observed in this exercise tended to be circular, or only slightly distorted from such a pattern, as shown in the preceding figures.

A very rough estimate was made of the overall reduction in dispersion as the number of rounds increased. On Round 1, the average IQR was about 39, whereas on the second round it dropped to 31. This is similar to the behavior observed by Dalkey in his experiments at Rand, in which the dispersion will be reduced successively between rounds, in the absence of relevant facts, but with no improvement in error (as measured by the mean or median estimate).[8-10] It is interesting to note that the average IQR on Round 3 was reduced to 29, with a range from 26 on ACE-0 (Termination of negotiations) to 32 on ACE-2 (Full agreement). One concludes that there is less of a consensus in the case in which a fairly full offensive and defensive agreement is effected.

RANKINGS OF TASKS AND SPECIFIC OBJECTIVES

Suppose we let ${}^{\mu}\pi_{\nu}$ denote the priority number for the νth alternative at the μth node, regardless of the normalization procedure used. In general, we shall assume a multiplicative rule of combination for the nodal assignments in order to obtain overall weights (relevance numbers) for the Task and Specific Objective levels. Thus, the relevance numbers for the Task ij, ij=11, 12, . . . , 43, are given by

$$r_{ij} = {}^{o}\pi_{i} \cdot {}^{i}\pi_{ij} , \qquad (1)$$

and the relevance numbers for the Specific Objective ijk, ijk=111, . . . , 433, are given by

$$r_{ijk} = {}^{o}\pi_{i} \cdot {}^{i}\pi_{ij} \cdot {}^{ij}\pi_{ijk} = r_{ij} \cdot {}^{ij}\pi_{ijk} . \qquad (2)$$

In the PATTERN scheme, the relevance numbers are computed by using the average of the normalized assignments at each node (the far right-hand column of data in the tabulation in Appendix D). The relevance numbers and rankings obtained from this data for the Tasks and the Specific Objectives are shown respectively in Table 2 and Table 3.

Inspection of Tables 2 and 3 reveals a very interesting and disturbing result, namely that Tasks

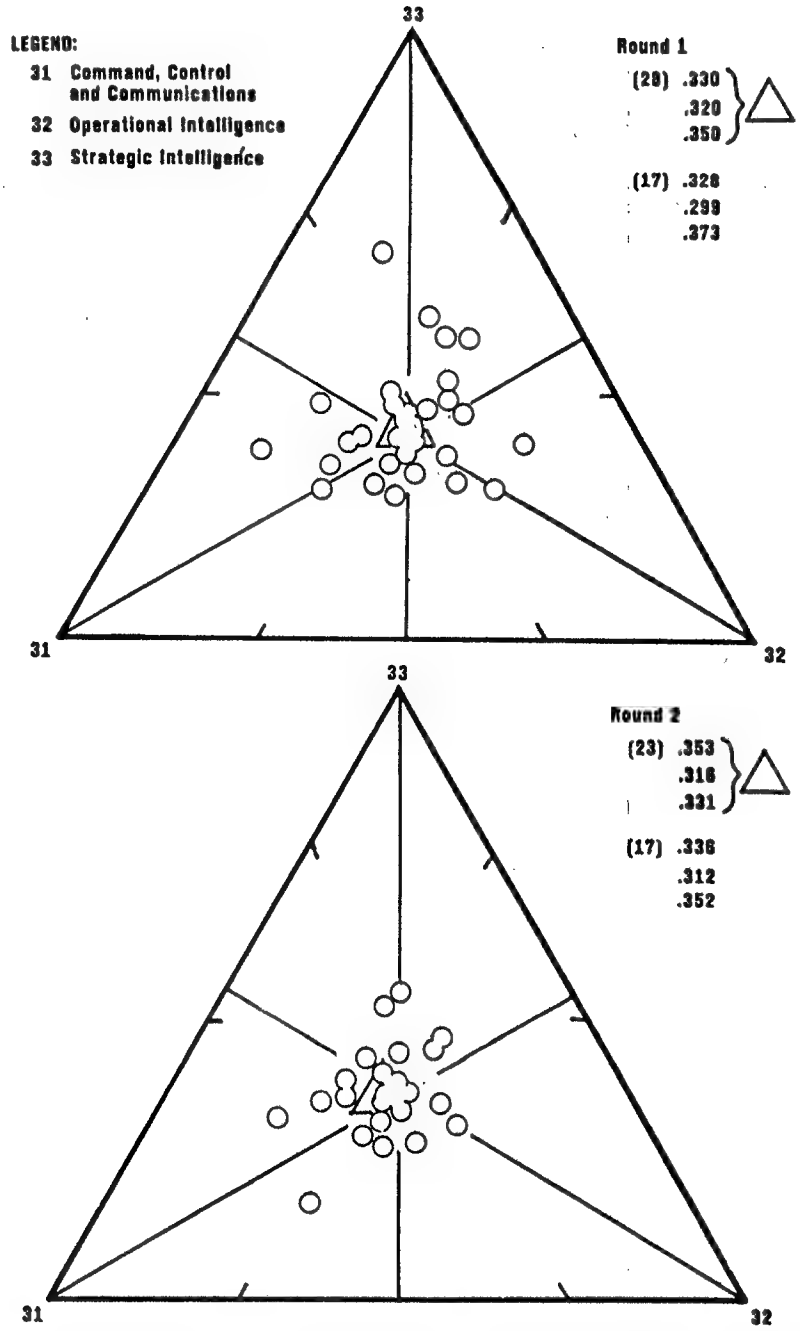

Figure 5. Barycentric Coordinate Representation of the Normalized Assignments at Node 3. The Tabulation Gives the Mean Assignments for the Entire Set of Data Collected and the Means for the Sub-set of Respondents Common to Round 3 (See Figure 6)

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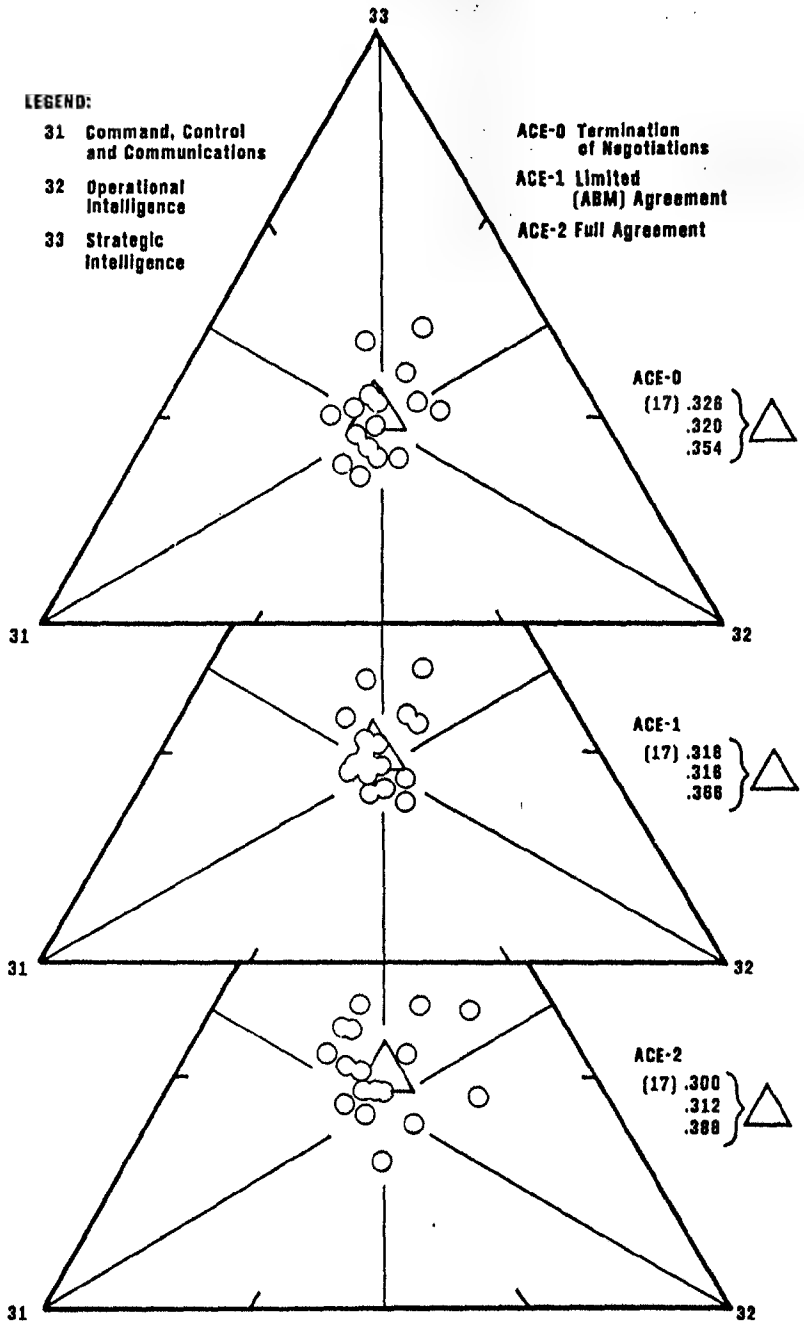

Figure 6. Barycentric Coordinate Representation of the Normalized Assignments at Node 3, Round 3, for Each of the ACE's Considered.

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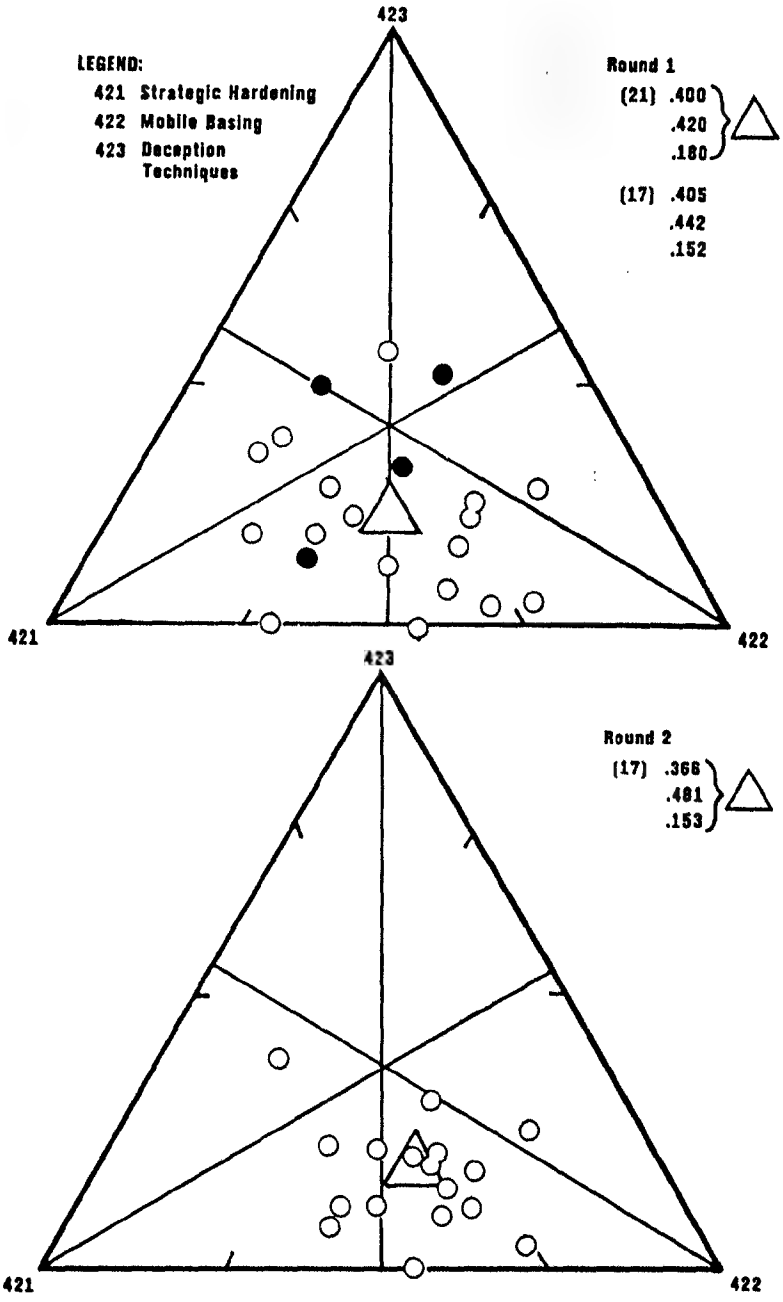

Figure 7. Barycentric Coordinate Representation of the Normalized Assignments at Node 42. The Four Responses Missing from Round 2 are Shown Shaded in Round 1.

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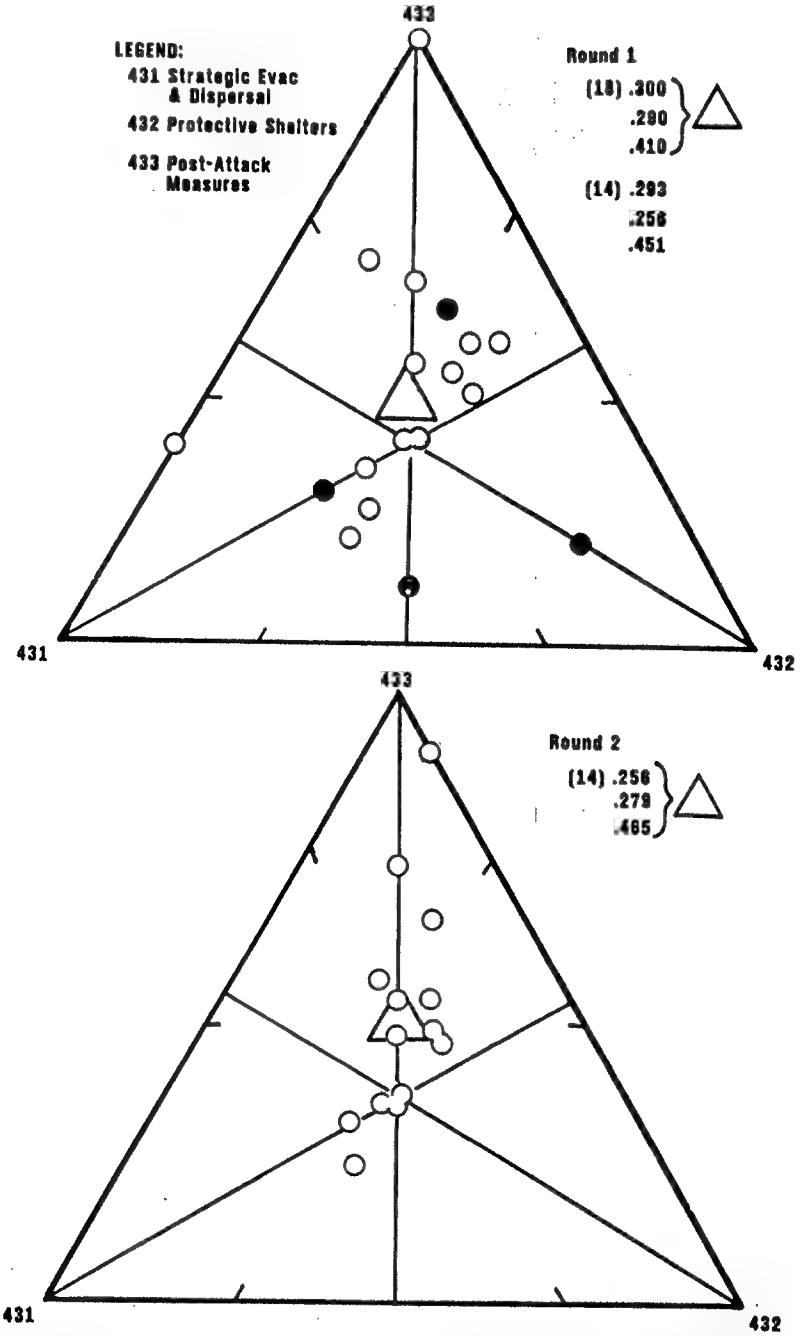

Figure 8. Barycentric Coordinate Representation of the Normalized Assignments at Node 43. The Four Respondents Missing in the Second Round are Shown Shaded in the First Round.

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Table 2

Relevance Numbers and Rankings for the Tasks as Obtained by the PATTERN Procedure

	Round 1		Round 2		Round 3*					
					ACE-0		ACE-1		ACE-2	
Task	Relevance	Rank	Relevance	Rank	Relevance	Rank	Relevance	Rank	Relevance	Rank
11	0.1188	2	0.1127	2	0.1282	2	0.1335	1	0.09157	6
12	0.0756	8	0.06521	10	0.07632	9	0.06878	10	0.0562	10
13	0.0756	9	0.08606	7	0.08352	6	0.0867	7	0.06922	9
21	0.10512	3	0.1037	3	0.09861	3	0.1037	4	0.1129	3
22	0.07488	10	0.07826	9	0.07439	10	0.07826	8	0.08514	7
31	0.0858	5	0.09355	4	0.08117	7	0.09349	5	0.1077	5
32	0.0832	6	0.08374	8	0.07968	8	0.0929	6	0.112	4
33	0.091	4	0.08772	6	0.08815	4	0.1076	3	0.1393	1
41	0.1682	1	0.1624	1	0.1653	1	0.1274	2	0.1189	2
42	0.0812	7	0.08959	5	0.08468	5	0.07168	9	0.0739	8
43	0.0406	11	0.03699	11	0.04002	11	0.03596	11	0.03322	11

*Round 3 computations used the nodal assignments from Round 2 for the eleven nodes not investigated explicitly in the third (ACE) round of the Delphi process.

21 and 22 and the Specific Objectives beneath them, particularly 211 and 212, seem to be rated too high. This over-rating is somewhat unexpected, considering the emphasis given to Element 2 at Node 0 (particularly exhibited in Figure 4) and the comments made by the respondents. An obvious source of this over-rating is the relevance tree structure itself: Node 2, in which the Tasks 21 and 22 are compared, is the only binary node in the tree and it seems reasonable, considering the nature of the PATTERN prescription, to suspect an automatic bias in the results. One notes that the Tasks under Element 2 will have a weight in the neighborhood of 0.5 whereas those elsewhere automatically have a weight near 0.33.

Suppose one were to have assigned equal weights to each element at each node in the tree. This no-choice, no-preference situation would, for the given tree structure, automatically result in a ranking or sorting of the Tasks and Specific Objectives as a result of the non-uniform splitting or branching of the tree. Although not completely correct, one might at least expect that a nearly impartial result would have obtained for the Tasks and Specific Objectives, given impartiality everywhere else. This train of thought leads one to attempt to correct the results obtained by PATTERN using some sort of comparison of those results with those which would be obtained in the no preference situation. In other words, it might be appropriate to consider rankings based on the magnitude of the ratio of the PATTERN relevance numbers to a set of numbers obtained by impartial (uniform) assignments at each node.* Although the viewpoint here is slightly different, the motivation for, and the results obtained from, this heuristic correction for structural bias are essentially identical to those given elsewhere.[11]

The ratios and associated rankings obtained by a modification of the PATTERN results are given in Tables 4 and 5. Some shifts from the previous results are to be observed, particularly the suppression of Tasks 21 and 22 and their subordinate Specific Objectives. On the other hand, violence has not been done for the most part to the positions of the other elements. No attempt has been made as yet to justify in detail this modified ranking, an analysis which might well be based, however, on the extensive Delphi-derived commentary of the participants.

*For the Tasks and Specific Objectives, these ratios are given respectively by

$$r_{ij}' = r_{ij}/(1/4)(1/n_i) = 4n_i r_{ij},$$
$$r_{ijk}' = 4n_i n_{ij} r_{ijk} = n_{ij} r_{ij}',$$

where

n_i = the number of alternatives at node i,
n_{ij} = the number of alternatives at node ij.

Table 3

Relevance Numbers and Rankings for the Specific Objectives as Obtained by the PATTERN Procedure

	Round 1		Round 2		Round 3 ACE-0		Round 3 ACE-1		Round 3 ACE-2	
SO	Relevance	Rank	Relevance	Rank	Relevance	Rank	Relevance	Rank	Relevance	Rank
111	0.02851	10	2.82947E-2	13	3.217E-2	9	3.351E-2	7	2.299E-2	18
112	0.03208	7	3.02111E-2	8	3.435E-2	6	3.578E-2	4	2.454E-2	17
113	0.0202	23	1.84874E-2	26	2.102E-2	22	2.190E-2	22	1.502E-2	33
114	0.02257	18	2.17565E-2	20	2.473E-2	17	2.577E-2	17	1.767E-2	29
115	0.01544	34	1.39783E-2	34	1.589E-2	30	1.656E-2	30	1.136E-2	38
121	0.01739	27	1.40849E-2	32	1.649E-2	28	1.486E-2	33	1.214E-2	36
122	0.01058	42	8.08579E-3	43	9.464E-3	43	8.529E-3	43	6.969E-3	43
123	0.01663	31	1.33024E-2	36	1.557E-2	31	1.403E-2	34	1.147E-2	37
124	0.031	8	2.97348E-2	9	3.480E-2	5	3.136E-2	11	2.563E-2	16
131	0.02268	17	2.62495E-2	15	2.547E-2	15	2.644E-2	15	2.111E-2	23
132	0.02419	16	2.55610E-2	16	2.481E-2	16	2.575E-2	18	2.056E-2	24
133	0.01814	25	2.16881E-2	21	2.105E-2	21	2.185E-2	23	1.744E-2	30
134	0.01058	43	1.25653E-2	37	1.219E-2	36	1.266E-2	37	1.011E-2	40
211	0.02838	11	2.92547E-2	10	2.781E-2	11	2.925E-2	12	3.183E-2	10
212	0.03574	4	3.50641E-2	5	3.333E-2	7	3.506E-2	5	3.815E-2	5
213	0.02733	13	2.73874E-2	14	2.603E-2	14	2.739E-2	14	2.980E-2	12
214	0.01367	37	1.20338E-2	38	1.134E-2	39	1.193E-2	38	1.309E-2	35
221	0.01647	32	1.63563E-2	30	1.555E-2	32	1.636E-2	32	1.779E-2	28
222	0.02172	19	2.41041E-2	18	2.291E-2	19	2.410E-2	21	2.622E-2	15
223	0.01647	33	1.67476E-2	28	1.592E-2	29	1.675E-2	28	1.822E-2	26
224	0.02022	22	2.10519E-2	22	2.001E-2	23	2.105E-2	24	2.290E-2	19
311	0.01716	28	1.91767E-2	25	1.664E-2	27	1.917E-2	26	2.208E-2	21
312	0.02059	21	2.46023E-2	17	2.135E-2	20	2.459E-2	19	2.833E-2	13
313	0.01201	39	1.40317E-2	33	1.218E-2	37	1.402E-2	35	1.616E-2	31
314	0.01888	24	1.93638E-2	24	1.680E-2	26	1.935E-2	25	2.229E-2	20
315	0.01716	29	1.63704E-2	29	1.421E-2	34	1.636E-2	31	1.885E-2	25
321	0.02662	14	2.83879E-2	12	2.701E-2	13	3.149E-2	10	3.797E-2	6
322	0.02746	12	2.88903E-2	11	2.749E-2	12	3.205E-2	9	3.864E-2	4
323	0.01747	26	1.58269E-2	31	1.506E-2	33	1.756E-2	27	2.117E-2	22
324	0.01165	41	1.06350E-2	40	1.012E-2	42	1.180E-2	39	1.423E-2	34
331	0.03003	9	3.27177E-2	7	3.288E-2	8	4.014E-2	3	5.196E-2	1
332	0.01456	36	1.13152E-2	39	1.137E-2	38	1.388E-2	36	1.797E-2	27
333	0.02093	20	1.98236E-2	23	1.992E-2	24	2.432E-2	20	3.148E-2	11
334	0.02548	15	2.38585E-2	19	2.389E-2	18	2.916E-2	13	3.789E-2	7
411	0.07905	1	7.48747E-2	1	7.505E-2	1	4.942E-2	1	4.636E-2	2
412	0.05214	2	5.24610E-2	2	5.207E-2	2	4.522E-2	2	4.042E-2	3
413	0.037	3	3.50823E-2	4	3.818E-2	4	3.273E-2	8	3.210E-2	9
421	0.03248	6	3.27899E-2	6	3.099E-2	10	2.623E-2	16	2.705E-2	14
422	0.0341	5	4.30928E-2	3	4.073E-2	3	3.448E-2	6	3.555E-2	8
423	0.01462	35	1.37073E-2	35	1.296E-2	35	1.097E-2	40	1.131E-2	39
431	0.01218	38	9.46995E-3	42	1.025E-2	41	9.204E-3	42	8.505E-3	42
432	0.01177	40	1.03208E-2	41	1.117E-2	40	1.003E-2	41	9.269E-3	41
433	0.01665	30	1.72013E-2	27	1.861E-2	25	1.672E-2	29	1.545E-2	32

Table 4

Ratios and Modified Rankings Obtained for the Tasks by an Application of Equation 3

	Round 1		Round 2		Round 3					
					ACE-0		ACE-1		ACE-2	
Task	Ratio	Rank	Ratio	Rank	Ratio	Rank	Ratio	Rank	Ratio	Rank
11	1.4313	2	1.358	2	1.544	2	1.600	1	1.103	5
12	0.9108	7	0.7856	9	0.9195	8	0.8287	9	0.6771	10
13	0.9108	8	1.037	6	1.006	5	1.045	6	0.834	8
21	0.8409	9	0.8299	8	0.7889	9	0.8299	8	0.9029	6
22	0.599	10	0.6261	10	0.5951	10	0.6261	10	0.6811	9
31	1.033	4	1.127	3	0.978	6	1.126	4	1.298	4
32	1.002	5	1.009	7	0.96	7	1.119	5	1.349	3
33	1.096	3	1.057	5	1.062	3	1.296	3	1.678	1
41	2.026	1	1.957	1	1.992	1	1.535	2	1.432	2
42	0.978	6	1.079	4	1.02	4	0.8636	7	0.8904	7
43	0.489	11	0.4457	11	0.4822	11	0.4332	11	0.4003	11

Suppose we postpone the normalization of the data and apply the multiplicative formulae using the non-normalized averages at each node (Appendix D, column A). The tabulation of the resultant products, normalized *after* multiplication, and the associated rankings for the Tasks and Specific Objectives are given in Tables 6 and 7 respectively. The significance of these results and the procedure employed to obtain them will be discussed in the following section, in which the various rankings are compared.

COMMENTS ON CORRELATIONS AND ARMS-CONTROL

Let us consider, as a simple means of comparison of the various rankings, the rank-difference correlation coefficient, given by *

$$\rho = 1 - 6\left\{\sum_{i=1}^{N} (X_i - Y_i)^2\right\} / N(N^2-1), \qquad (3)$$

where N is the number of ordered pairs (X_i, Y_i), and X_i and Y_i are the rankings of the ith element in the two rankings considered. Perfect agreement is indicated by $\rho = +1$, while $\rho = -1$ indicates exactly opposite rankings.

*Dixon, W. J., and F. J. Massey. Introduction to Statistical Analysis, New York, McGraw-Hill, 1957, p 294-295.

It is of interest to compare the non-PATTERN rankings introduced in the previous section to the PATTERN rankings and to one another. The correlation between PATTERN and its modification varies, depending on the round and the tree level, but typically is of the order of 0.85. The correlation between PATTERN and the third approach, the product of the non-normalized averages (PNNA) is worse, typically about 0.70. In the final possibility, we find the correlation between the modified PATTERN (ratio) and the PNNA to be quite high, on the order of 0.92. This final result is very interesting because it means that comparable results are obtained from the modification of PATTERN to account for tree structure and the perfectly straight-forward results obtained from multiplication of the non-normalized nodal averages. Suppose the modified PATTERN results are correct. Then it appears as if normalization at a node results in a loss of information (reflecting on tree structure) which has to be reintroduced mathematically. On the other hand, collecting and combining non-normalized data with no corrective action is appealing in its simplicity and very attractive in terms of its correlation with modified PATTERN. Non-normalized nodal assignments obviously contain more information content than normalized assignments, and it is possible that accommodation to the tree structure is part of this content. Using

Table 5

Ratios and Modified Rankings Obtained for the Specific Objectives by an Application of Equation 4

	Round 1		Round 2		Round 3 ACE-0		Round 3 ACE-1		Round 3 ACE-2	
SO	Ratio	Rank	Ratio	Rank	Ratio	Rank	Ratio	Rank	Ratio	Rank
111	1.711	4	1.69769E0	4	1.930E0	3	2.011E0	2	1.379E0	10
112	1.925	2	1.81267E0	3	2.061E0	2	2.147E0	1	1.473E0	8
113	1.212	14	1.10924E0	20	1.261E0	13	1.314E0	12	9.011E-1	26
114	1.354	7	1.30539E0	11	1.484E0	7	1.546E0	6	1.060E0	18
115	0.9266	23	8.38697E-1	27	9.535E-1	23	9.934E-1	22	6.813E-1	32
121	0.8346	28	6.76077E-1	30	7.913E-1	27	7.131E-1	30	5.827E-1	34
122	0.508	39	3.88118E-1	40	4.543E-1	40	4.094E-1	39	3.345E-1	41
123	0.7983	29	6.38517E-1	32	7.473E-1	28	6.735E-1	32	5.503E-1	37
124	1.488	5	1.42727E0	8	1.670E0	5	1.506E0	9	1.230E0	14
131	1.089	19	1.25998E0	13	1.223E0	14	1.269E0	13	1.013E0	21
132	1.161	16	1.22603E0	14	1.191E0	15	1.236E0	15	9.868E-1	22
133	0.8709	26	1.04103E0	21	1.010E0	19	1.049E0	21	8.373E-1	29
134	0.508	40	6.03137E-1	34	5.853E-1	34	6.076E-1	34	4.851E-1	38
211	0.9082	24	9.36150E-1	24	8.899E-1	24	9.361E-1	25	1.018E0	19
212	1.144	17	1.12205E0	19	1.067E0	18	1.122E0	20	1.221E0	15
213	0.8746	25	8.76396E-1	25	8.331E-1	26	8.764E-1	26	9.534E-1	25
214	0.4373	42	3.85083E-1	41	3.629E-1	43	3.818E-1	41	4.189E-1	39
221	0.5272	36	5.23403E-1	37	4.975E-1	37	5.234E-1	38	5.694E-1	35
222	0.6949	32	7.71331E-1	28	7.332E-1	29	7.713E-1	29	8.391E-1	28
223	0.5272	37	5.35924E-1	36	5.094E-1	36	5.359E-1	37	5.830E-1	33
224	0.647	33	6.73662E-1	31	6.403E-1	33	6.737E-1	31	7.329E-1	30
311	1.03	20	1.15060E0	17	9.984E-1	21	1.150E0	19	1.325E0	12
312	1.236	11	1.47614E0	7	1.281E0	12	1.475E0	10	1.700E0	5
313	0.7207	30	8.41906E-1	26	7.306E-1	30	8.414E-1	28	9.693E-1	24
314	1.133	18	1.16183E0	16	1.008E0	20	1.161E0	18	1.338E0	11
315	1.03	21	9.82223E-1	22	8.523E-1	25	9.817E-1	23	1.131E0	17
321	1.278	10	1.36262E0	10	1.297E0	11	1.512E0	8	1.823E0	3
322	1.318	9	1.38674E0	9	1.320E0	10	1.538E0	7	1.855E0	2
323	0.8387	27	7.59690E-1	29	7.229E-1	31	8.428E-1	27	1.016E0	20
324	0.5591	35	5.10480E-1	38	4.857E-1	38	5.663E-1	36	6.828E-1	31
331	1.441	6	1.57045E0	5	1.578E0	6	1.927E0	3	2.494E0	1
332	0.6989	31	5.43132E-1	35	5.458E-1	35	6.663E-1	33	8.625E-1	27
333	1.005	22	9.51533E-1	23	9.502E-1	22	1.167E0	17	1.511E0	7
334	1.223	13	1.14521E0	18	1.147E0	16	1.400E0	11	1.819E0	4
411	2.846	1	2.69549E0	1	2.702E0	1	1.779E0	4	1.669E0	6
412	1.877	3	1.88860E0	2	1.875E0	4	1.628E0	5	1.455E0	9
413	1.332	8	1.26206E0	12	1.375E0	9	1.178E0	16	1.155E0	16
421	1.169	15	1.18044E0	15	1.116E0	17	9.444E-1	24	9.737E-1	23
422	1.228	12	1.55134E0	6	1.466E0	8	1.241E0	14	1.280E0	13
423	0.5262	38	4.93463E-1	39	4.664E-1	39	3.948E-1	40	4.071E-1	40
431	0.4385	41	3.40919E-1	43	3.688E-1	42	3.314E-1	43	3.062E-1	43
432	0.4239	43	3.71548E-1	42	4.020E-1	41	3.611E-1	42	3.337E-1	42
433	0.5993	34	6.19247E-1	33	6.699E-1	32	6.019E-1	35	5.561E-1	30

Table 6

Normalized Products and Rankings for the Tasks Using Non-Normalized Averages as the Nodal Assignments

	Round 1		Round 2		Round 3					
					ACE-0		ACE-1		ACE-2	
Task	Product	Rank	Product	Rank	Product	Rank	Product	Rank	Product	Rank
11	0.120	2	0.116	2	0.142	2	0.129	2	0.071	5
12	0.076	8	0.071	8	0.090	7	0.074	7	0.051	10
13	0.089	6	0.096	6	0.094	6	0.089	6	0.062	8
21	0.059	9	0.056	9	0.052	9	0.058	9	0.068	6
22	0.051	10	0.051	10	0.046	10	0.052	10	0.061	9
31	0.112	4	0.115	3	0.103	4	0.127	3	0.155	2
32	0.107	5	0.110	4	0.100	5	0.124	4	0.155	
33	0.114	3	0.108	5	0.110	3	0.143	1	0.194	1
41	0.153	1	0.153	1	0.142	1	0.106	5	0.091	4
42	0.079	7	0.088	7	0.082	8	0.068	8	0.065	7
43	0.040	11	0.037	11	0.036	11	0.030	11	0.027	11

the PNNA scheme is certainly interesting, if not rigorously supportable at this time. If such a procedure were justified, its use would represent a significant departure from the PATTERN prescription.

It is doubtful that the results will vary significantly, for the raw data obtained in this exercise, if meaningful statistical quantities other than the average are used at a node. For example, in Round 2, if one selects the normalized medians of the distributions as the characteristic nodal assignments and computes rankings by the PATTERN process, a correlation of about 0.96 obtains between this ranking and that of the PATTERN processing of averages of normalized assignments. As another example, correlations of better than 0.98 are observed for rankings obtained from the latter procedure and those derived from PATTERN processing of the normalized averages (the figures in Appendix D, column NA).

Inspection of the tables of rankings reveals that in a large proportion of the cases, the rank of a Task or Specific Objective on Round 2 agrees or falls within the range of ranks observed in the three ACE cases. In part, Round 2 tends to correspond with ACE-0 or ACE-1, as might have been expected. Using the rank correlation coefficient and considering, as an example, the modified PATTERN or PNNA results, the correlations (for the Tasks) between Round 2 and ACE-0, 1, and 2, respectively, are about 0.94, 0.90, and 0.72. For the Specific Objectives, the corresponding correlations are about 0.98, 0.96, and 0.85, where the shift to higher values is due to the fact that the Round 2 values were used on the eleven nodes not specifically examined under the three ACE's in order to compute overall rankings.

On any given round or ACE, it does not matter for ranking if normalization of the PNNA's is performed, although this has been done for the results given in Tables 6 and 7. Normalization is preferred if a single set of numbers is desired for a given round or ACE. On the other hand, normalization may be inappropriate when comparing the magnitudes of the various numbers used to obtain the rankings of the elements for various ACE's, since this normalization may be destroying information content. Figures 9 and 10 illustrate the behavior of the non-normalized products of the non-normalized averages for the Tasks and a portion of the Specific Objectives, as a function of ACE. In both figures, the ordinate is the fraction of the maximum possible value. Since there are three levels in the tree and each element at each node can have a value of 100, the maximum possible score for a Specific Objective PNNA is 10^6. A better feeling for the behavior of elements in the tree may accrue from inspection of Figures 9 and 10.

Table 7

Normalized Products and Rankings for the Specific Objectives Using Non-Normalized Averages as the Nodal Assignments

	Round 1		Round 2		Round 3 ACE-0		Round 3 ACE-1		Round 3 ACE-2	
SO	Product	Rank	Product	Rank	Product	Rank	Product	Rank	Product	Rank
111	3.871E-2	5	4.050E-2	6	4.895E-2	3	4.420E-2	4	2.446E-2	15
112	4.379E-2	2	4.321E-2	2	5.222E-2	2	4.716E-2	2	2.609E-2	12
113	2.800E-2	15	2.728E-2	18	3.297E-2	10	2.977E-2	14	1.648E-2	26
114	3.222E-2	13	3.181E-2	11	3.844E-2	6	3.471E-2	10	1.921E-2	20
115	2.211E-2	24	2.103E-2	25	2.542E-2	20	2.295E-2	22	1.270E-2	32
121	1.315E-2	31	1.159E-2	33	1.435E-2	29	1.176E-2	33	8.090E-3	36
122	8.871E-3	39	7.609E-3	39	9.423E-3	36	7.723E-3	38	5.311E-3	40
123	1.176E-2	34	1.066E-2	35	1.320E-2	30	1.082E-2	35	7.439E-3	37
124	2.284E-2	23	2.225E-2	23	2.755E-2	17	2.258E-2	23	1.554E-2	29
131	2.575E-2	17	2.968E-2	14	2.888E-2	15	2.709E-2	16	1.884E-2	21
132	2.575E-2	18	2.740E-2	17	2.666E-2	18	2.501E-2	18	1.740E-2	23
133	2.184E-2	25	2.550E-2	19	2.482E-2	22	2.328E-2	19	1.619E-2	27
134	1.314E-2	32	1.542E-2	27	1.501E-2	27	1.408E-2	30	9.789E-3	35
211	1.423E-2	29	1.432E-2	28	1.291E-2	31	1.430E-2	29	1.712E-2	25
212	1.660E-2	27	1.686E-2	26	1.519E-2	26	1.684E-2	27	2.015E-2	18
213	1.357E-2	30	1.346E-2	31	1.213E-2	33	1.344E-2	31	1.609E-2	28
214	7.196E-3	40	6.033E-3	41	5.438E-3	41	6.026E-3	40	7.212E-3	39
221	1.025E-2	37	9.979E-3	37	8.995E-3	38	9.967E-3	36	1.193E-2	33
222	1.183E-2	33	1.271E-2	32	1.146E-2	34	1.270E-2	32	1.520E-2	30
223	9.627E-3	38	8.635E-3	38	7.783E-3	39	8.624E-3	37	1.032E-2	34
224	1.167E-2	35	1.112E-2	34	1.002E-2	35	1.110E-2	34	1.329E-2	31
311	3.424E-2	10	3.362E-2	10	2.973E-2	14	3.620E-2	9	4.479E-2	7
312	3.978E-2	4	4.231E-2	4	3.741E-2	7	4.556E-2	3	5.637E-2	2
313	2.340E-2	21	2.400E-2	22	2.122E-2	24	2.584E-2	17	3.198E-2	10
314	3.636E-2	8	3.409E-2	9	3.014E-2	13	3.670E-2	8	4.541E-2	6
315	3.242E-2	12	2.917E-2	15	2.580E-2	19	3.141E-2	13	3.887E-2	9
321	3.444E-2	9	3.694E-2	8	3.309E-2	9	4.064E-2	6	5.141E-2	5
322	3.663E-2	7	3.847E-2	7	3.447E-2	8	4.233E-2	5	5.355E-2	4
323	2.380E-2	20	2.114E-2	24	1.894E-2	25	2.326E-2	20	2.943E-2	11
324	1.579E-2	28	1.411E-2	30	1.264E-2	32	1.553E-2	28	1.965E-2	19
331	3.842E-2	6	4.086E-2	5	4.106E-2	4	5.280E-2	1	7.260E-2	1
332	1.903E-2	26	1.428E-2	29	1.435E-2	28	1.846E-2	25	2.538E-2	13
333	2.666E-2	16	2.507E-2	20	2.519E-2	21	3.240E-2	12	4.455E-2	8
334	3.301E-2	11	3.051E-2	13	3.066E-2	12	3.943E-2	7	5.421E-2	3
411	5.654E-2	1	5.710E-2	1	5.775E-2	1	3.273E-2	11	2.537E-2	14
412	4.010E-2	3	4.252E-2	3	4.041E-2	5	2.966E-2	15	2.242E-2	16
413	3.185E-2	14	2.910E-2	16	3.100E-2	11	2.199E-2	24	1.728E-2	24
421	2.327E-2	22	2.416E-2	21	2.237E-2	23	1.829E-2	26	1.770E-2	22
422	2.420E-2	19	3.052E-2	12	2.825E-2	16	2.310E-2	21	2.235E-2	17
423	1.092E-2	36	9.980E-3	36	9.248E-3	37	7.561E-3	39	7.318E-3	38
431	4.584E-3	43	3.348E-3	43	3.219E-3	43	2.668E-3	43	2.349E-3	43
432	5.043E-3	42	4.118E-3	42	3.959E-3	42	3.282E-3	42	2.890E-3	42
433	6.565E-3	41	7.532E-3	40	7.243E-3	40	6.003E-3	41	5.287E-3	41

For example, one notes from Figure 10 that Element 331 may not be in as strong a first-place position in ACE-2 as is Element 411 in ACE-0, as is implied by the normalized products in Table 7. The truth is probably somewhere between the normalized and non-normalized cases.

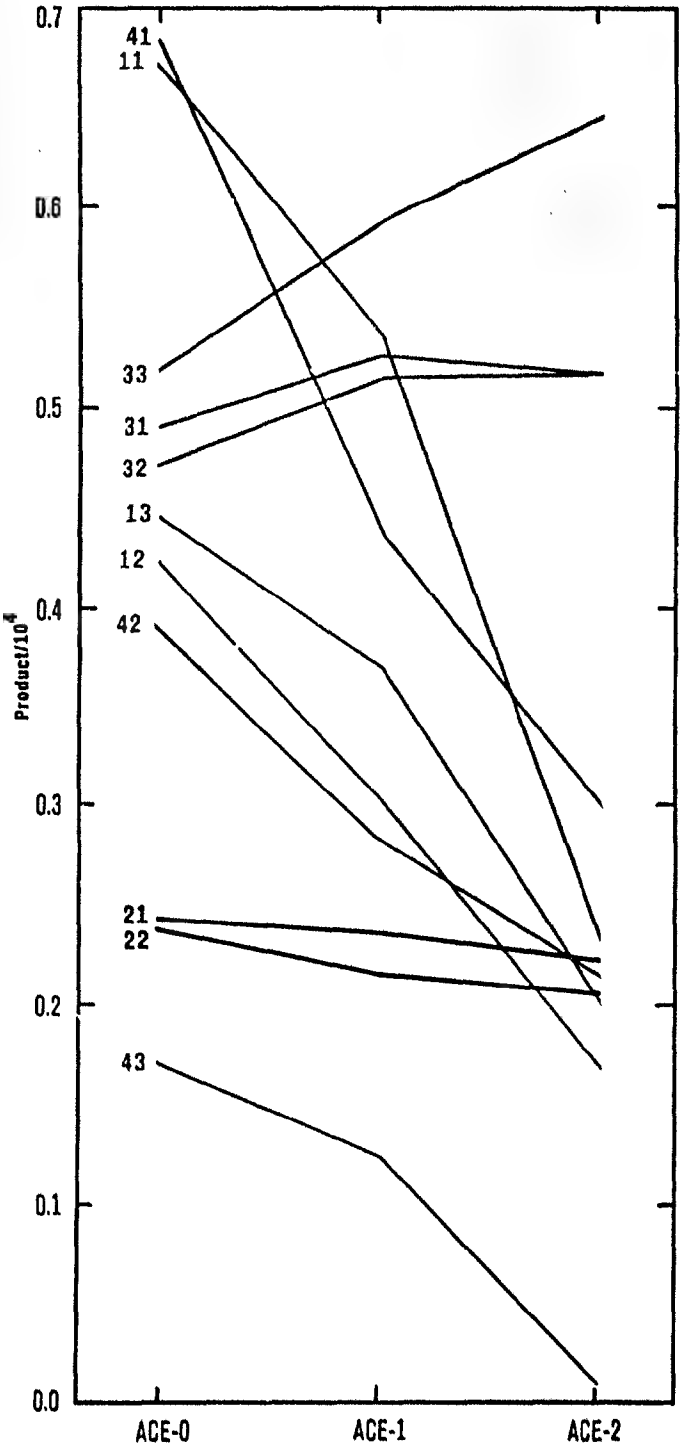

Figure 9. Non-normalized Products of the Non-Normalized Averages for the Tasks, as a function of Arms-Control Environment (ACE).

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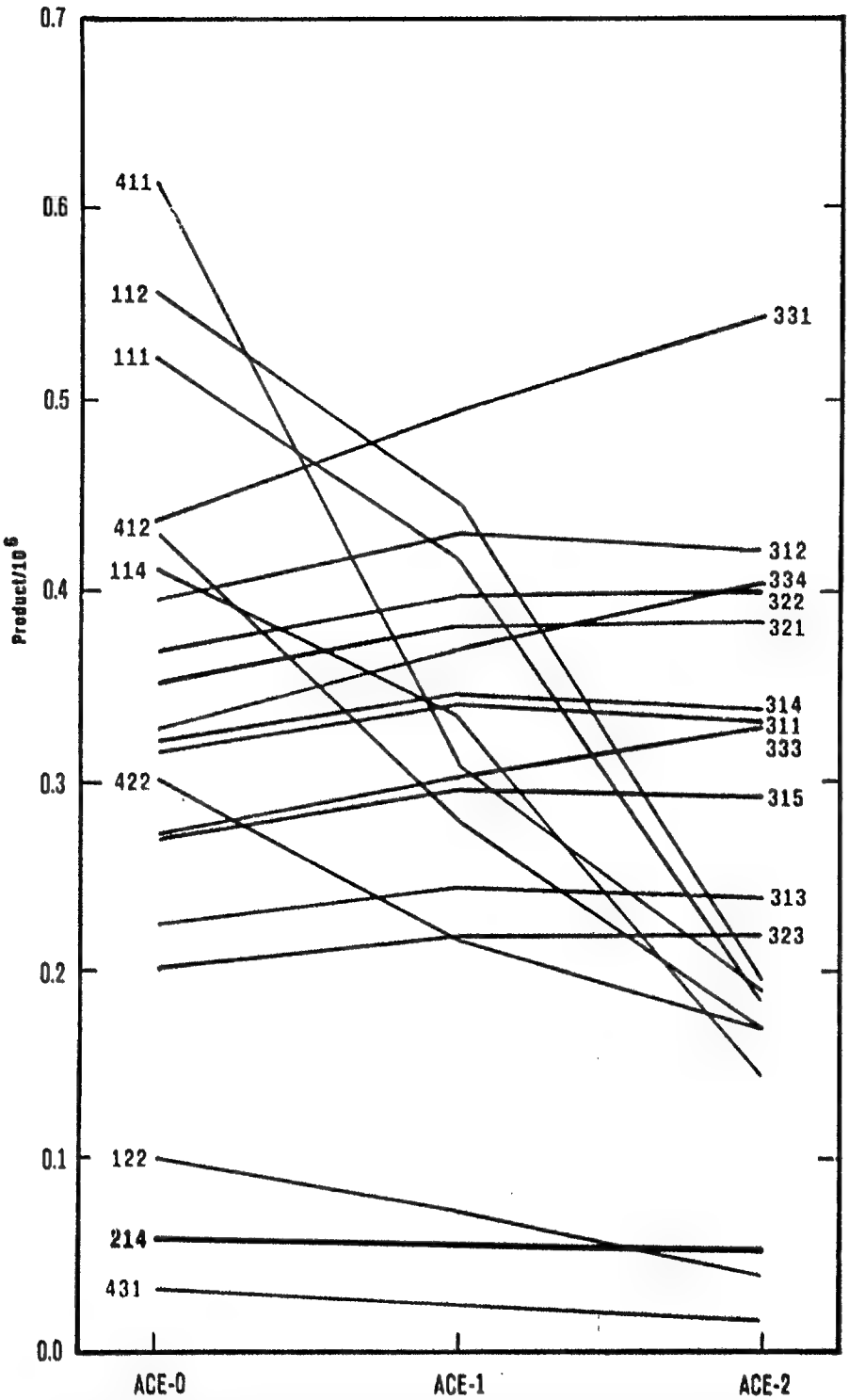

Figure 10. Non-normalized Products of the Non-normalized Nodal Averages for a Selection of Specific Objectives. For Clarity, Only the Upper 17 and Lowest 3 Specific Objectives are Shown; the Remaining 23 Would Fill the Apparant Gap.

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APPENDIX A

NATURE OF THE EXERCISE

Some important background material was provided to the participants in the Delphi Exercise in the instruction booklet prepared specifically for this. Material describing the Delphi technique itself is reproduced in this Appendix, along with the discussion provided as the rationale for the selection of priority as a basis for evaluation, and suggested criteria for evaluation. Appendix B contains the complete set of definitions for the elements in the relevance tree, also given in the booklet. The material which discussed the scaling procedures for the numerical assignments is given in part of Appendix C.

THE DELPHI TECHNIQUE [8-10 13]

Delphi is the term given to the process developed at Rand for eliciting and systematically refining the opinions of expert individuals. Because it is based on the intuition and speculation of individuals, it appears to be especially useful in problems of forecasting. The main features of the Delphi technique are:

Anonymous response
Iteration and controlled feedback
Statistical group response.

Anonymous Response

In the Delphi technique, the opinions of the participants are obtained by formal questionnaire. Debate is replaced by a program of sequential interrogations, At no time are the members of the expert group in direct contact with one another. All communication is through a central clearinghouse or a project director. The degree and nature of the interactions in the Delphi panel can be controlled, whereas a face-to-face group interaction tends to introduce uncontrollable factors. Group interactive procedures necessarily require that each person explain, defend, or promote his position with possible attendant grandstanding, prestige-seeking, and a hardening of positions. Groups may also exhibit a band-wagon effect with opinions based on those of the ranking or dominant individuals. The advantages derived from the Delphi method are that it requires less time than a conference and each respondent works essentially at his own speed and at his convenience.

Iteration and Controlled Feedback

The interactions in a Delphi exercise are effected by conducting one or more iterations with controlled feedback between rounds. The feedback may be in the form of (i) the median and quartiles of the group responses on the preceding round, or (ii) relevant facts, information, or opinion. In each round, the participants are invited to revise their previous opinions and may be asked to provide reasons in support of them.

Statistical Group Response

The opinion of the group is defined or represented as an appropriate aggregate of the individual opinions obtained on the final round. Typically the median of the individual responses is used. Such a definition of group response admits a spread of opinions without coercive conformity, i.e., it reduces group pressure and insures that every member is represented in the final response.

The above aspects of Delphi help to minimize the biasing effects of dominant individuals, irrelevant communications, and group pressure toward conformity. Adoption of the Delphi technique is advantageous in view of indications that the procedure leads to an enhanced acceptance of the group response over that obtained through more conventional procedures.

An additional feature of the Delphi work at Rand is the *self-rating*.[9] It appears that a meaningful estimate of the accuracy of the group response to a given question might be obtained by combining the individual self-ratings of the competence of an individual into a group rating.

Expertise and Accuracy

On the question of accuracy, a few remarks are in order, based on the Rand experience with Delphi. It has been observed that the accuracy of the Delphi estimates is generally improved as the number of respondents is increased. The accuracy of the estimates sometime decreases, however, as the time allowed for a response increases. Finally, it has been noted in some Delphi experiments that "the most significant parameter in the experiment is likely to be how much the individual members know about the subject matter."[8]

THE PREMISE FOR PRIORITY ASSESSMENT

An illuminating overview of the intelligence problem that the [redacted] methodology is intended to address has been set down by the late Allen Dulles.[14] His statement forms a kind of manifesto for the development of this methodology:

> One general range of subjects that receives constant attention and very frequent, regular estimates is the development of what we call military hardware, particularly by the Soviet Union. This means Soviet programs and progress in missiles, nuclear warheads, nuclear submarines, advanced type aircraft and anything that might approach a breakthrough in any of the sectors of this field, as well as in the field of space. This is one of the most difficult tasks which face the intelligence estimator.
>
> Here one has to deal with Soviet capabilities to produce a given system, the role assigned to the system by the military, and its true priority in the whole military field.
>
> It is always difficult to predict how much emphasis is given to any particular system until the research and development stage has been completed, the tests of effectiveness have been carried out, and the factories have been given the order to proceed with actual production. As long as a Soviet system is still in its early stages, our estimates will stress capabilities and probable intentions; as hard facts become available, it is possible to give an actual estimate of programming the system.

The phrase "priority in the whole military field" is considered relevant to this exercise, forming a succinct statement of the role of the relevance tree portion of the [redacted] methodology. It is intended that an evaluation of Soviet priority will include not only an evaluation of needs and incentives but also a measure of the likelihood that action would be taken to carry out a program or a development.

CRITERIA OR BASES FOR EVALUATION

In the holistic approach employed in this exercise, the balloter is not given explicit criteria or bases for an evaluative comparison of the alternatives or elements at a node. The balloter is expected to assign weights to the elements taking into account simultaneously the various possible considerations that might obtain. The procedure does not require an independent evaluation of the alternatives on a criterion-by-criterion basis. The participants in the exercise were reminded, however, of some possible criteria that might be reviewed before assigning weights to the alternatives.

One possible general set of criteria that might be used in the tree for Strategic (General) Warfare is:

- Military considerations
- Diplomatic considerations
- Economic constraints
- Psycho-cultural considerations

Here, one simultaneously considers the priorities of the alternatives at a node from the military, diplomatic, economic, and psycho-cultural points of view and assigns an overall priority number to each alternative. It may be assumed that various irrational factors which might be involved in Soviet decision-making, as well as factors dictated by history or tradition, are considered within the psycho-cultural criterion.

Alternatively, a collection of criteria might well be cast in the form suggested in a paper on trade-off studies.[15] Criteria suggested for the trade-off of forces implementing national policies are:

- Versatility
- Deterrent capability
- Expandability
- National acceptability
- International acceptability

These criteria might be appropriate at about the Mission level of the relevance tree.

Yet another suggested set of criteria that may be involved in weapons procurement decisions is:

Cost-effectiveness and economic impact
Strategic uncertainties
Technological obsolescence
Objectives and policy desiderata

The suggested criteria or potential bases for evaluation were not required to be applied strictly at every node of interest. They were cited only to remind the balloter of the myriad of considerations that could be taken into account in the assignment of priority numbers. It was suggested also that some attempt be made to factor SALT into the considerations at some of the node, possibly in the form of assumed agreements.*

*This casual approach to the uncertainties concerning SALT and future arms control environments was felt to be quite unsatisfactory, however, and a modification was made on the third round of the Delphi exercise, as described elsewhere (Appendix C).

APPENDIX B

THE RELEVANCE TREE FOR STRATEGIC (GENERAL) WARFARE

The relevance tree is intended to assist in the identification and evaluation of areas of Soviet priority to improve significantly or upgrade an existing capability. Thus, the emphasis is on isolating and defining significantly improved systems or novel weapons concepts that might obtain in a future Soviet strategic force posture.

The relevance tree was constructed with a number of subordinate desiderata in mind. First, it was desired that the number of nodes and alternatives at a node be kept reasonably low so as to make implementation tractable and reasonably economical. Second, because of theoretical reasons, it was desired that approximately the same low number of alternatives or branch elements occur at each node on a given level.[16-18] Third, the members of the Specific Objectives level should all be reasonably compatible with one another in terms of their complexity and content. Fourth, it was hoped that reasonably neutral descriptions and definitions could be employed. Finally, it was desired that as many nodes as possible be constructed such that their evaluations might have some significance and interpretability independent of the overall process.

The relevance tree for Strategic (General) Warfare is shown schematically in Figure 2, and the definitions used for its elements are given below. The definition of this element in the Spectrum of Conflict is intended to encompass the strategies referred to in the United States as 'assured destruction' and 'damage limitation'. This element embraces weapons of mass destruction which are generally intercontinental in terms of capability. The weapons and countermeasures may have deterrence as their primary purpose and thus may not ever be used.

DEFINITIONS OF RELEVANCE TREE ELEMENTS

Strategic (General) Warfare — Node 0

Armed conflict between major powers in which the total resources of the belligerents are employed and the national survival of one or more of the belligerents is in jeopardy.[1]

Mission Definitions		Element #
Strike	The destruction, incapacitation, or neutralization of enemy strategic offensive and defensive forces and resources, including strategic missiles, aircraft, naval forces, orbital systems, defensive measures, warning and intelligence functions, transportation, communication, military and industrial value targets, and population centers.	1
Logistics/ Support	The deployment of strategic forces and materiel to remote or distant areas for purposes of support for offensive or defensive missions, to perform strategic interdiction of continental areas, to permit "third world" operations, and to obtain such psychological and strategic benefits associated with "conspicuous deployment."	2
Intelligence/ Warning/ Control	The acquisition, processing, analysis, and dissemination of information (operational or national, tactical or strategic, basic or topical) concerning the resources, forces, and actions of extant and potential enemies prior to and during general or strategic conflict; warning of attack; and the direction and control of the movement and application of strategic forces and resources.	3
Defense	The protection, by active or passive means, of selected point and/or area targets (civilian or military) by destruction, incapacitation, degradation, or neutralization of attacking weapons, exclusive of the defensive or protective contribution of the warning, intelligence/reconnaissance, and command/control/communications systems.	4

[1] Joint Chiefs of Staff, Dictionary of United States Military Terms for Joint Usage, Washington, D.C., JCS Pub. 1, 1 Jan 66, U.

Node 1

Tasks Definitions	Element #
The destruction, incapacitation, or neutralization of enemy strategic offensive forces (missiles, strategic bomber aircraft, naval forces, and orbital weapons).	11
The destruction of enemy resources and value targets, including cities and population centers, military and industrial value targets, civilian transportation systems, and civilian communication systems.	12
The destruction, incapacitation, or neutralization of enemy strategic defenses, command, control, communications, early warning, and intelligence systems.[2]	13

Node 11

Specific Objectives Definitions	Element #
The destruction, incapacitation, or neutralization of land-based strategic missiles. The missiles may be fixed or mobile and may be based in the polar ice caps and possibly the shallow territorial waters.	111
The destruction, incapacitation, or neutralization of enemy strategic weapons located or based below the surface of international waters and/or beneath the polar ice caps.[3]	112
The destruction, incapacitation, or neutralization of enemy surface naval strategic forces (aircraft carriers, missile launching vessels, and strategic transport vessels).[3]	113
The destruction, incapacitation, or neutralization of enemy strategic aerodynamic threats, such as manned strategic bombers and cruise missiles.	114
The destruction, neutralization, or incapacitation of enemy strategic threats based on, or consisting of, orbital space platforms or natural bodies in space.	115

[2] Systems supporting this task will contribute to a capability to destroy or significantly degrade the enemy's ABM or interceptor aircraft, the early warning and control systems for these defensive measures, as well as the command, control and force management capability for the enemy's offensive weaponry. Systems or programs specifically directed towards key personnel in the chain of command are included under this task also.

[3] Note that these Specific Objectives do not include the detection, identification and tracking aspects of the ASW or surface naval problem. Only the "kill" capability is considered here.

Node 12

Specific Objectives Definitions	Element #
The destruction of enemy cities and population centers.	121
The destruction or disruption, either temporarily or for an extended period of time, of enemy transportation systems which serve primarily civilian purposes and needs.	122
The destruction or disruption, either temporarily or for an extended period, of enemy communication systems which serve the civilian sector.	123
The destruction of selected military and industrial value targets.	124

Node 13

Specific Objectives Definitions	Element #
The destruction, incapacitation, or neutralization of enemy regional or national defensive forces intended to counter a strategic attack.[4]	131
The destruction, incapacitation, or neutralization of enemy command, control, and communication systems specifically intended for strategic military tasks.	132
The destruction, incapacitation, or neutralization of enemy strategic warning and national intelligence systems.[5]	133
The destruction or incapacitation of selected special targets or personnel critically involved in enemy strategic planning, intelligence, and/or command and control.	134

[4] Systems responsive to this Specific Objective are those whose primary mission is the attack on the defensive systems. Those systems or subsystems which are a part of an offensive weapon system and play a secondary or supportive role to that system are not considered here.

[5] Systems responsive to this Specific Objective are those whose primary mission is the destruction of such targets. Subsystems of offensive systems which serve to support that system and to neutralize or degrade enemy warning capability are not included here.

Node 2

Tasks Definitions	Element #
The transportation of forces, weapons, or materiel to any point or area on the earth in order to provide support for offensive and defensive measures on a worldwide basis.[6]	21
The establishment of bases for weapons or personnel in remote locations. (These bases are nominally stationary or relatively slowly moving or are not characterized by their mobility per se. These bases are characterized by the relative harshness of the environment and have strategic value because of it.)[7]	22

Node 21

Specific Objectives Definitions	Element #
The transportation of forces, weapons, or materiel by aircraft or lighter-than-air vehicles in support of strategic offensive and defensive missions.[8]	211
The transportation of forces, weapons, or materiel in or on bodies of water, providing sealift support capabilities for offensive and defensive strategic missions.[9]	212
The transportation of forces, weapons, or materiel over land in support of strategic offensive and defensive missions.[10]	213
The transportation of forces, weapons, or materiel via space vehicles or platforms.[11]	214

[6] Systems supporting this task will provide an airlift and sealift capability for long-range air and naval operations, the patrol of large areas, and the supply of remote bases. Mobile land systems of a strategic nature are included under this task.

[7] Systems or basing facilities supporting this task are manned and unmanned space/orbital platforms, surface and subsurface ocean platforms, and terrestrial bases and installations in conditions of extreme environment such as the arctic or rugged high-altitude regions.

[8] Systems responsive to this Specific Objective include large transport aircraft, tankers, and patrol and reconnaissance aircraft. Large aircraft which may serve as command and control centers and as support platforms for strategic weapons are also included.

[9] This Specific Objective covers submarines, surface naval vessels, and "interface" vehicles such as GEMs and SESs. Such systems are intended to provide support for long-range naval operations, patrol and reconnaissance, and resupply and logistic support.

[10] This Specific Objective represents logistic support, mobile reconnaissance and patrol, and mobile launch platforms for strategic weapons. Of particular interest are those systems capable of maneuvering in hostile environments and those which support long-range penetration into regions contiguous to the Soviet Union.

[11] Includes the development of low-cost reusable boosters and spacecraft and advanced shuttle vehicles.

Node 22

Specific Objectives Definitions	Element #
The deployment and basing of weapons, personnel, or materiel in space or in earth orbit or on natural bodies in space.[12]	221
The deployment and basing of weapons, personnel, or materiel beneath the surface of bodies of water.[13]	222
The deployment and basing of weapons, personnel, or materiel on the surface of bodies of water.[14]	223
The deployment or basing of weapons, personnel, or materiel on land, particularly in an extreme or hostile environment.[15]	224

Node 3

Tasks Definitions	Element #
The planning, direction, and control of the movement and application of strategic forces and resources in a conflict environment.[16]	31
The acquisition and analysis of information necessary for the planning, conduct, and direction of military operations.[17]	32
The collection, analysis, evaluation, and dissemination of information, not specifically designated for military missions, for the purpose of estimating and assessing extant and potential enemy capabilities and intentions. Such information is intended to provide support to policymakers and provide guidance for long-range national planning.[18]	33

[12] Systems responsive to this Specific Objective would include reconnaissance platforms, deep space command and/or bombardment platforms, etc.

[13] Systems responsive to this Specific Objective will include manned and unmanned submarine platforms which are relatively fixed in location.

[14] Systems responsive to this Specific Objective are, for example, aircraft and missile carriers or platforms which are slowly moving or fixed in location.

[15] Such bases would be located in arctic or polar regions, mountainous or high-altitude areas, or deserts.

[16] Systems responsive to this task assist in information processing, analysis, and dissemination; decision-making; and force management and force allocation.

[17] Systems supporting this task include those for ASW and naval reconnaissance and surveillance; satellite detection and tracking; acquisition of general reference materials and data for planning pertaining to the capabilities, resources, and potential areas of operations.

[18] Systems or programs embraced by this task include those pertaining to the analysis and estimation of foreign capabilities and intentions, future threats, verification of arms limitations, early warning systems, and post-attack assessment.

Node 31

Specific Objectives Definitions	Element #
The planning, direction, and control of the movement and application of Soviet strategic aerospace offensive forces (Strategic Rocket Troops and Long Range Aviation).[19]	311
The planning, direction, and control of the movement and application of Soviet naval forces.	312
The planning, direction, and control of Soviet space missions.	313
The planning, direction, and control of the Soviet aerospace defensive forces.	314
The transmission of information by a combination of systems incorporated into an integrated and standardized point-to-point network serving the Soviet state, military, industrial, civil, and party telecommunication needs.	315

Node 32

Specific Objectives Definitions	Element #
The detection, identification, and tracking of satellites and orbital platforms, preferably before their first pass over the Soviet Union. (May include, for identification purposes, a close inspection and/or boarding or docking by Soviet vehicles.)	321
The detection, identification, and tracking of naval ships and vessels, including submarines and subsurface platforms, as well as military and civilian surface traffic.	322
The acquisition of global geographic and geodetic surveys and mappings, surveys of terrestrial magnetism, and oceanographic data pertinent to military missions.	323
The acquisition, analysis, and utilization of meteorological data, including global electromagnetic activity (thunderstorms, solar flares, etc.), for synoptic and tactical weather prediction.	324

[19] A launch-on-warning capability is included in this Specific Objective.

Node 33

Specific Objectives Definitions	Element #
The detection and early warning of strategic attack on the Soviet Union.[20]	331
The determination of the nature and extent of damage inflicted on the enemy and the damage sustained by the Soviet Union in a strategic exchange and the generation of information pertinent to subsequent actions, including recovery and the termination of hostilities.	332
The detection and evaluation of long-term threats and the estimation of future enemy intentions and capabilities.	333
The collection and evaluation of information, not designated specifically for military missions, on the current and projected (near-term) strategic force deployment, characteristics, and capabilities of extant and potential enemies.[21]	334

Node 4

Tasks Definitions	Element #
Direct defensive action taken to destroy or reduce the effectiveness of attacks by enemy aerospace vehicles or threats, including strategic ballistic missiles, aircraft and cruise missiles, and orbital weapons.[22]	41
Defensive actions, other than active measures and warning systems, taken to reduce the probability of, and minimize the effects of damage by, an attack from an enemy strategic aerospace strike.[23]	42
The protection of the population and the entire national wealth from the effects of "weapons of mass destruction" (nuclear, chemical, and bacteriological weapons).[24]	43

[20] Systems responsive to this Specific Objective may include those for the detection of launch of enemy offensive strategic weapons, a long-range high-capacity system for target acquisition and tracking, and systems for the detection of weapon detonation.

[21] This Specific Objective includes the means for verification of a possible limitation on strategic arms.

[22] This task is concerned with the active point and area defense of civilian and military targets by missiles, interceptor aircraft, artillery, electronic countermeasures, etc.

[23] This task is essentially the passive defense of military targets by deceptive techniques, dispersion, mobility, and protective construction (hardening).

[24] This task is essentially the passive defense of the civilian sector by evacuation, dispersal, protective shelters, and those measures intended to provide rescue and emergency work and to perpetuate the national economy in a wartime environment.

Node 41

Specific Objectives Definitions	Element #
The active protection of selected point and/or area targets, civilian or military, from an attack by enemy strategic ballistic missiles (ICBMs and SLBMs).	411
The active protection of selected point and/or area targets, civilian or military, from an attack by enemy strategic aircraft and cruise missiles.	412
The active protection of the Soviet Union from an attack by orbital and space-based threats.	413

Node 42

Specific Objectives Definitions	Element #
The protection of selected military installations and strategic forces by protective construction or basing techniques (hardening).	421
The protection of selected military facilities, control centers, or weapons (offensive or defensive) by mobility or the use of mobile basing concepts.	422
The protection of selected military installations and facilities by deceptive techniques (cover, camouflage, concealment, etc.).	423

Node 43

Specific Objectives Definitions	Element #
The dispersal of workers and employees from installations of the national economy and the evacuation of the population from large cities and the more important industrial centers.[25]	431
The sheltering of people collectively in protective structures and the provision of individual means of protection against blast, thermal radiation, and radioactivity.	432
Measures directed toward increasing the ability of important sectors of the economy, all types of transportation, communications and utilities, and industrial power supplies to survive an attack and function in wartime.	433

[25] The evacuation and dispersal are "strategic," i.e., accomplished in advance of an attack and dependent upon adequate warning of that attack. (Tactical evacuation is the relatively hasty withdrawal immediately prior to or after the launch of an attack.) Dispersal is the organized removal of the population from enterprises of industry, transport, and communication—which do not cease functioning in wartime—from large cities to predetermined areas outside the cities. Evacuation is the transportation of the nonworking population, primarily children, old people, disabled and sick persons, from large cities to predetermined areas.

APPENDIX C

ORGANIZATION AND CONDUCT OF THE DELPHI EXERCISE

The Delphi elicitation of nodal priority numbers covered the period Nov 70 – Apr 71. The exercise began with a series of individual briefings to prospective participants. At that time, an instruction booklet [12] and some associated descriptive materials describing the background for the exercise were provided to the participant. One nodal questionnaire and an Administrative Questionnaire were also left with the participant. The Administrative Questionnaire contained a self-rating section in which the participant indicated on a simple 1-5 scale his opinion as to his relative expertness on the 16 nodes in the relevance tree. An opportunity was presented for the respondent to indicate a simple preference for a few nodes to be involved with and the respondent was asked to indicate others that he felt might contribute to the exercise. Finally, the Administrative Questionnaire asked the respondent for permission to be identified as a participant in the exercise, with the understanding that specific responses would not be attributed by name and that opinions expressed are personal and professional and need not reflect official Agency views. All participants were assigned a code number for the exercise.

Almost all participants in the exercise were assigned five nodes in the relevance tree to consider in the exercise. One of these nodes was assigned initially by the Project Director (Nodes 0-4), while the remaining four were allocated on the basis of the Administrative Questionnaires returned. Every attempt was made to insure that participants were contributing in areas in which they felt competent, but at the same time, maintaining a 'mix' of backgrounds and Agency components for all of the nodes.

Slightly over 100 people were approached for participation. Of these, 99 indicated a willingness to contribute. Agency personnel from all Directorates were involved. There was, as expected, some loss of participation over the course of the exercise, amounting to about 24% at its termination. The initial and final distributions of participants is given in the table below.

Component	Initial	Final
	99	75

Of the 75 participants who contributed throughout the entire exercise, about 39% were analysts; 36% were supervisory personnel from Branch Chiefs through Division Chiefs; 13% were from staffs such as ONE and NIPE; 12% were Office Directors and Deputy Directors.

A few comments might be made concerning the self-rating and the resultant biasing of the sample for expertness. On the scale 1-5, where 5 represents a high assessment of expertness, the overall average group self-rating for all nodes by all participants was about 2.9. In contrast, the overall average self-rating for the participants on the nodes they were involved with was about 3.9, with a high of 4.5 on Node 41 to a low of 3.1 on Node 2. On Node 0, which was assigned without the benefit of the Administrative Questionnaire, the average group self-rating was 3.7.

Assignment of Priority Numbers—Scaling Procedure

The participants in the exercise were called upon to supply two types of information or expressions

of opinion: numerical assignments of priority and comments or statements supporting these assignments. The Delphi Questionnaires consisted of two basic parts. Part A was concerned with the numerical assessment of priority. The Specific Objectives level in the relevance tree is to have a set of weights (relevance numbers) associated with it and these weights should in some sense reflect the degrees to which upgrading the individual Specific Objectives would enhance higher-level Soviet goals. To this end, priority was selected as the key concept in the evaluation of the elements in the relevance tree. Time was not handled explicitly in the assessments, i.e., there was no attempt to break the basic 5-15 year period into segments.

A typical Part A questionnaire was of the form indicated below:

> To meet national goals and objectives over the next 5 to 15 year period, the Soviet Union may seek to improve significantly or upgrade their capabilities in (title of node). What is the relative priority that you feel the Soviets would place on obtaining *significant* improvement or upgrading in each of the elements supporting this objective? (Assign a priority number to each of the elements below, using a scale 0-100, where 0=no priority, 100=top priority.)
>
> Element # ..... (Title) .....
> Element # ..... (Title) .....
>
> .
> .
> .
>
> Element # ..... (Title) .....

A rather unusual 0-100 scale was used for the numerical assignments of priority in this exercise. A value of 100 was intended to denote the feeling that a top priority is given by the Soviets for obtaining a truly significant improvement in capability. A value of 0 was intended as a reflection of no priority, however, it was not to be interpreted as meaning that no effort would be expended in that area. An element rated 0 may well have improvements, but the 0 indicates that the Soviets do not attach a real priority to their realization. Intermediate levels of priority are reflected by numbers between 0 and 100. The scale and its associated definitions are intended to reflect emphasis on improvement and not simply a resource allocation. A respondent could reflect relative priority between alternatives at a node as well as an overall priority, since he was not required to assign a 100. Alternative approaches which were rejected were the normalized, or 'split-100', method in which the sum of the assignments at a node is fixed, and the method in which a fixed amount is assigned to the highest alternative at the node (the so-called '100-top' method). The normalized approach was felt to be too restrictive and might tend to lead to conservative assignments. More information is conveyed by the selected procedure than by either the 'split-100' or '100-top' methods. The procedure selected is interestingly similar to the '100-top' method, for which recent work by Dalkey tends to support as preferable over the 'split-100' in Delphi examinations of relative value.[10]

Non-Numerical Responses and Feedback Materials

Part B of the Delphi Questionnaires was involved with the elicitation of comments concerning the priorities, i.e., the respondent was asked to indicate what he had in mind when he made the assignments. These brief supporting statements provide an outlet for qualification of the numerical assignments and enabled respondents to indicate trends that are not apparent from the simple numeric values.

The most important application of the comments made in Part B of the questionnaires was in the feedback material provided to the respondents after each round. In addition to some statistical information which described the previous round's results (median and inter-quartile range), the feedback material contained a compilation of the comments made by the respondents. This material amounted to some 2-9 pages of verbatim text or quotations arranged in appropriate groups and identified for communication purposes by the participant's ID number. The comments were edited slightly and sometimes paraphrased, but were, for the most part, complete comments provided by the respondents. There was no attempt made to synthesize groups of comments or to abstract individual or collected comments. The feedback material was classified and restricted to the Secret level.

An Investigation of Sensitivity to Arms-Control

Two complete rounds of a Delphi process were carried out on all sixteen nodes in the relevance tree. The results obtained from Round 2 (described in detail elsewhere) indicated that it would not be particularly advantageous to pursue additional rounds. A review of the results and com-

ments indicated, however, that it would be quite desirable to carry out a third round with some modification in the basic questionnaire on a few selected nodes to determine their sensitivity to arms-control. It was quite evident that some of the dispersion in the assignments was due to uncertainties about future arms-control environments.

In order to assess the extent of the dispersion due to the mixture of assumptions concerning SALT and future arms-control environments and to estimate the sensitivity of the results to these contingencies, five nodes (0, 1, 3, 4, 41) were selected for further investigation by asking for priority numbers for the elements at these nodes under three given hypothetical arms-control environments or scenarios. The basis for selection was partly the frequency with which SALT or arms-control assumptions were cited in Part B of the Delphi Questionnaires for the first and second rounds.

The three hypothetical Arms-Control Environments (ACE's) considered are described below. These definitions were derived from open literature sources [19-21] and are purely hypothetical, with an eye for extremes. They were not intended to be entirely realistic or even achievable and it was suggested to the participants that they attempt to assign priority numbers *assuming* the existence of a given ACE and to avoid arguing the viability or likelihood of that ACE.

For the partial Round 3, the numerical portion (Part A) of the Delphi Questionnaires was of the following revised form:

> To meet national goals and objectives over the next 5 to 15 year period, the Soviet Union may seek to improve significantly or upgrade their capabilities in (title of node). For each of the hypothetical Arms-Control Environments, what is the relative priority that you feel the Soviets would place on obtaining *significant* improvement or upgrading in each of the elements supporting this objective. (Assign a priority number to each on a 0-100 scale, where 0=no priority, 100=top priority.)
>
> | | ACE 0 | ACE 1 | ACE 2 |
> |---|---|---|---|
> | Element # .... (Title) | ..... | ..... | ..... |
> | . . | . | . | . |
> | Element # .... (Title) | ..... | ..... | ..... |

Hypothetical Arms-Control Environments

ACE 0 Negotiations between the US and the SU are terminated within the next year with little likelihood of a resumption of SALT in the near future. Assume, however, that treaties and agreements already in effect (or nearly so) remain in force (i.e., the 1963 Nuclear Test Ban; the banning of bombs in orbit; the agreement to maintain Latin America as a nuclear weapons-free zone; the 1968 Nuclear Non-Proliferation Treaty; and the treaty banning weapons on the seabed).

ACE 1 A limited arms-control agreement is arrived at within the next year. Assume an agreement which restricts deployment of ABM's to the National Command Authority (NCA) of the SU and the US (i.e., Moscow and Washington). Assume that talks continue for the purpose of negotiating additional agreements.

ACE 2 A relatively full arms-control agreement is arrived at within the next year or so. Assume an agreement in which: ABM deployments are restricted to the NCA; offensive strategic weapons are frozen at then-current levels and types (missiles and aircraft) with a ban on the construction of new launchers and a restriction on any changes in deployed systems to those that do not change their external characteristics; MIRV warhead flight testing, production, and deployment is banned and the US removes such warheads already deployed on their Minuteman and Poseidon missiles. Assume that talks continue toward possible additional agreements.

The revised questionnaires contained an array, rather than a single column as in the first two rounds, to be filled with priority numbers. As before, normalization was not required. The respondents were reminded of the importance of obtaining appropriate relative assignments within a column but that consistency across a row was desirable and secondary in importance.

APPENDIX D

TABULATION OF NODAL RESULTS

The following table contains a compilation, by node, of the priority numbers elicited in the exercise. The table presents the results for the two complete rounds for all nodes and the results of the third round for the five nodes examined under the hypothetical Arms-Control Environments.

The number in parentheses at the left is the number of respondents for the given node-round. Reading across from the left, the columns contain the following quantities: the element ID number; the first or lower quartile (Q_1); the median (M); the third or upper quartile (Q_3); the average (mean) of the responses (A); the normalized average (NA); and the average of the set of normalized responses (ANR).

			Q_1	M	Q_3	A	NA	ANR
NODE 0								
Rnd 1	(49)	1	50	75	90	69.3	.270	.270
		2	25	50	65	47.8	.186	.180
		3	50	65	80	66.2	.257	.260
		4	50	80	95	73.8	.287	.290
Rnd 2	(44)	1	50	75	80	67.3	.266	.264
		2	25	50	65	46.9	.186	.182
		3	50	70	80	65.3	.258	.265
		4	60	80	90	73.2	.290	.289
Rnd 3	(30)	1	60	85	100	79.2	.285	.288
ACE-0		2	30	50	65	49.2	.177	.173
		3	60	70	80	69.8	.251	.249
		4	70	80	90	80.0	.287	.290
Rnd 3	(30)	1	50	70	100	72.8	.282	.289
ACE-1		2	30	50	60	48.2	.187	.182
		3	65	75	90	75.8	.293	.294
		4	50	60	75	61.5	.238	.235
Rnd 3	(30)	1	30	35	70	48.5	.216	.217
ACE-2		2	25	40	50	45.8	.204	.198
		3	60	90	100	78.8	.351	.359
		4	40	50	70	51.3	.229	.226
NODE 1								
Rnd 1	(33)	11	55	80	90	71.9	.422	.440
		12	40	50	75	45.2	.266	.280
		13	30	50	80	53.1	.312	.280
Rnd 2	(30)	11	60	75	90	70.7	.409	.427
		12	25	50	60	43.6	.252	.247
		13	35	60	75	58.5	.339	.326
Rnd 3	(19)	11	75	85	100	84.5	.433	.445
ACE-0		12	40	50	70	53.4	.275	.265
		13	50	50	70	56.3	.290	.290
Rnd 3	(19)	11	60	75	90	73.4	.441	.462
ACE-1		12	30	40	50	42.1	.253	.238
		13	30	50	70	50.8	.306	.300
Rnd 3	(19)	11	40	50	50	48.4	.387	.422
ACE-2		12	20	30	50	34.5	.276	.259
		13	25	40	50	42.1	.337	.319

			Q_1	M	Q_3	A	NA	ANR
NODE 2								
Rnd 1	(21)	21	40	50	60	51.2	.536	.584
		22	20	45	80	44.3	.464	.416
Rnd 2	(16)	21	35	50	55	49.4	.527	.570
		22	20	45	70	44.4	.473	.430
NODE 3								
Rnd 1	(28)	31	50	80	90	70.2	.337	.330
		32	50	70	80	66.4	.319	.320
		33	50	75	90	71.8	.344	.350
Rnd 2	(23)	31	60	75	75	72.4	.345	.353
		32	50	70	75	69.3	.330	.316
		33	50	70	80	68.0	.325	.331
Rnd 3	(17)	31	60	80	80	69.7	.329	.326
ACE-0		32	60	70	80	67.6	.319	.320
		33	65	70	90	74.4	.352	.354
Rnd 3	(17)	31	60	70	80	69.1	.322	.318
ACE-1		32	60	70	80	67.6	.315	.316
		33	70	80	90	77.9	.363	.366
Rnd 3	(17)	31	45	70	85	65.3	.307	.300
ACE-2		32	45	75	80	65.3	.307	.312
		33	80	90	95	81.8	.386	.388
NODE 4								
Rnd 1	(29)	41	80	100	100	85.9	.560	.580
		42	30	50	65	44.7	.291	.280
		43	10	20	30	22.9	.149	.140
Rnd 2	(27)	41	80	100	100	85.9	.550	.562
		42	40	50	60	49.3	.316	.310
		43	10	20	25	20.9	.134	.128
Rnd 3	(14)	41	85	90	100	85.7	.551	.570
ACE-0		42	25	50	65	48.6	.312	.292
		43	10	20	25	21.4	.137	.138
Rnd 3	(14)	41	50	75	90	71.1	.518	.542
ACE-1		42	25	45	60	45.7	.333	.305
		43	10	20	25	20.4	.149	.153
Rnd 3	(14)	41	40	50	75	58.9	.499	.526
ACE-2		42	20	45	60	42.1	.356	.327
		43	5	15	25	17.1	.145	.147
NODE 11								
Rnd 1	(25)	111	55	80	90	71.6	.235	.240
		112	70	85	100	81.0	.266	.270
		113	30	50	80	51.8	.170	.170
		114	40	70	80	59.6	.195	.190
		115	20	45	60	40.9	.134	.130
Rnd 2	(23)	111	80	90	90	77.8	.247	.251
		112	75	90	95	83.0	.264	.268
		113	40	50	70	52.4	.167	.164
		114	50	70	75	61.1	.194	.193
		115	20	40	60	40.4	.128	.124

NODE 12

		Q_1	M	Q_3	A	NA	ANR
Rnd 1 (23)	121	10	50	70	38.7	.232	.230
	122	10	20	50	26.1	.157	.140
	123	10	25	50	34.6	.208	.220
	124	50	75	90	67.2	.403	.410
Rnd 2 (21)	121	10	35	50	36.1	.223	.216
	122	10	15	35	23.7	.146	.124
	123	10	25	50	33.2	.204	.204
	124	50	75	85	69.3	.427	.456

NODE 13

Rnd 1 (19)	131	30	60	100	64.5	.298	.300
	132	40	70	90	64.5	.298	.320
	133	25	70	80	54.7	.253	.240
	134	10	20	50	32.9	.152	.140
Rnd 2 (18)	131	40	75	100	68.9	.303	.305
	132	50	65	80	63.6	.280	.297
	133	25	65	80	59.2	.260	.252
	134	10	40	50	35.8	.157	.146

NODE 21

Rnd 1 (14)	211	40	55	70	53.6	.276	.270
	212	50	60	75	62.5	.322	.340
	213	25	55	60	51.1	.263	.260
	214	5	15	50	27.1	.139	.130
Rnd 2 (13)	211	50	60	70	56.5	.282	.282
	212	50	60	80	66.5	.333	.338
	213	35	60	65	53.1	.266	.264
	214	10	10	40	23.8	.119	.116

NODE 22

Rnd 1 (13)	221	10	25	75	44.6	.236	.220
	222	45	50	70	51.5	.273	.290
	223	25	30	75	41.9	.222	.220
	224	40	60	75	50.8	.269	.270
Rnd 2 (12)	221	10	45	75	43.8	.234	.209
	222	40	55	70	55.8	.300	.308
	223	20	30	50	37.9	.203	.214
	224	35	50	70	48.8	.263	.269

NODE 31

Rnd 1 (14)	311	40	80	85	67.9	.206	.200
	312	70	90	100	78.9	.239	.240
	313	30	35	70	46.4	.141	.140
	314	70	75	90	72.1	.219	.220
	315	50	70	80	64.3	.195	.200
Rnd 2 (11)	311	50	80	85	65.0	.206	.205
	312	70	90	95	81.8	.259	.263
	313	30	40	65	46.4	.147	.150
	314	60	80	80	65.9	.209	.207
	315	45	60	75	56.4	.179	.175

		Q_1	M	Q_3	A	NA	ANR
NODE 32							
Rnd 1 (16)	321	60	80	85	72.2	.311	.320
	322	75	75	100	76.8	.331	.330
	323	25	55	65	50.0	.215	.210
	324	20	30	40	33.1	.143	.140
Rnd 2 (13)	321	70	80	80	74.6	.333	.339
	322	70	80	90	77.7	.348	.345
	323	30	50	60	42.7	.191	.189
	324	20	30	30	28.5	.128	.127
NODE 33							
Rnd 1 (21)	331	50	90	100	74.5	.328	.330
	332	10	30	55	36.9	.162	.160
	333	20	50	80	51.7	.228	.230
	334	50	75	80	64.0	.282	.280
Rnd 2 (16)	331	75	90	100	84.1	.369	.373
	332	15	25	45	29.4	.129	.129
	333	20	45	80	51.6	.226	.226
	334	50	80	80	62.8	.276	.272
NODE 41							
Rnd 1 (26)	411	60	90	100	82.2	.440	.470
	412	30	70	80	58.3	.312	.310
	413	20	40	70	46.3	.248	.220
Rnd 2 (22)	411	70	90	95	83.0	.444	.461
	412	40	70	80	61.8	.330	.323
	413	20	40	65	42.3	.226	.216
Rnd 3 (13) ACE-0	411	80	90	100	89.6	.447	.454
	412	50	75	80	62.7	.313	.315
	413	25	45	70	48.1	.240	.231
Rnd 3 (13) ACE-1	411	55	75	90	70.4	.388	.388
	412	50	65	80	63.8	.352	.355
	413	30	45	70	47.3	.260	.257
Rnd 3 (13) ACE-2	411	45	60	85	62.7	.390	.390
	412	35	55	80	55.4	.345	.340
	413	20	50	60	42.7	.265	.270
NODE 42							
Rnd 1 (21)	421	50	60	80	65.0	.398	.400
	422	35	80	90	67.6	.415	.420
	423	10	30	45	30.5	.187	.180
Rnd 2 (17)	421	50	60	80	61.2	.374	.366
	422	70	80	90	77.3	.472	.481
	423	15	30	30	25.3	.154	.153
NODE 43							
Rnd 1 (18)	431	10	20	40	25.0	.283	.300
	432	15	20	30	27.5	.311	.290
	433	10	30	60	35.8	.406	.410
Rnd 2 (14)	431	10	20	25	20.0	.223	.256
	432	10	20	30	24.6	.274	.279
	433	10	35	80	45.0	.503	.465

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